Course Structure & Syllabus

Master of Technology
Computer Science & Engineering

(Effective from the academic Session 2020-2021)

Department of Computer Science & Engineering and Applications
Sambalpur University Institute of Information Technology (SUIIT)
Sambalpur University, Jyoti Vihar-768019, Burla

Program Outcomes

PO1	Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions
PO2	Effective Communication: Will be able to speak, read, write and listen clearly in person and through electronic media in English and in one Indian Language.
PO3	Social Interaction (Interpersonal Relation): Elicit views of others, mediate disagreements and prepared to work in team.
PO4	Entrepreneurship Capability: Demonstrate qualities to be prepared to become an entrepreneurship.
PO5	Ethics: Recognize different value systems including your own, understand the moral dimensions and accept responsibility for them.
PO6	Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.
PO7	Life-Long Learning: Acquire the ability to engage in independent and life-long learning in the context of socio-technological changes.

Course Structure
(Master of Technology in Computer Science and Engineering)

Semester – I						
Code	**Course Title**	**Category**	**L**	**P**	**T**	**Credits**
CS 611	Mathematical Foundations of Computer Science	Foundation Course	4	0	0	**4**
CS 612	Advanced Data Structures and Algorithms	Core Course	4	0	0	**3**
CS 613	Advanced Programming Languages	Core Course	3	0	1	**3**
XX XXXX	Elective –I	Professional Elective	3	0	1	**3**
XX XXXX	Elective –II	Professional Elective	3	0	1	**3**
CS 614	Open source lab-I	Core Course	0	3	0	**2**
CS 615	Advanced Programming Languages lab.	Core Course	0	3	0	**2**
CS 616	Seminar & Technical Writing-I	Technical Seminar	-	-	-	**2**
					Total Credit:	**22**

Semester – II						
Code	**Course Title**	**Category**	**L**	**P**	**T**	**Credits**
CS 621	Cryptography and Network Security	Core Course	4	0	0	**4**
CS 622	Data Warehousing and Data Mining	Core Course	4	0	0	**4**
XX XXXX	Elective –III	Professional Elective	3	0	0	**3**
XX XXXX	Elective –IV	Professional Elective	3	0	1	**3**
XX XXXX	Elective –V	Professional Elective	3	0	0	**3**
CS 623	Network programming lab.	Core Course	0	3	0	**2**
CS 624	Seminar & Technical Writing-II	Technical Seminar	-	-	-	**2**
					Total Credit:	**21**

Semester – III			
Code	**Course Title**	**Category**	**Credits**
CS 631	Dissertation Review-I	Project Work	**20**
		Total Credit:	**20**

Semester – IV			
Code	**Course Title**	**Category**	**Credits**
CS 641	Final Dissertation Review	Project Work	**20**
		Total Credit:	**20**

SEMESTER WISE CREDIT DISTRIBUTION					
Semester	**I**	**II**	**III**	**IV**	**TOTAL**
Total Credit	22	21	20	20	83

Elective Pool (for Elective-I to Elective – V)	
CS 6E01	Artificial Intelligence
CS 6E02	Information retrieval and web search
CS 6E03	Pattern Recognition
CS 6E04	Advanced Computer Networking
CS 6E05	Advanced Databases
CS 6E06	Advanced Computer Architecture
CS 6E07	Mobile Computing
CS 6E08	Principles of Programming Languages
CS 6E09	Intellectual Property Rights and Cyber Laws
CS 6E10	Formal Languages and Automata Theory
CS 6E11	Image Processing
CS 6E12	High Performance Computing
CS 6E13	Internet of Things
CS 6E14	Storage Area Networks
CS 6E15	Game Theory
CS 6E16	Software define network
CS 6E17	Machine Learning
CS 6E18	Big Data Analytics
CS 6E19	Cloud Computing
CS 6E20	Soft Computing
CS 6E21	Real time system
CS 6E22	Software Engineering
CS 6E23	Wireless Sensor Network & Applications
CS 6E24	Semantic Web and Social Networking
CS 6E25	Advanced Operating Systems
CS 6E26	Software Project Management
CS 6E27	Parallel algorithms
CS 6E28	Probability &Stochastic Process
CS 6E29	Time Series Analysis
CS 6E30	Computer Based Numerical and Statistical Methods

Special Instructions:

- **Selection of Electives**: Choose Electives from elective pool. Electives will be offered based on availability of concerned course instructor.
- **SEMINAR AND TECHNICAL WRITING-I&II:** Student will review research papers published in referred journals (at least six different papers in an installment of two seminars). In this work student will prepare and display posters, prepare and submit synopsis, give seminar on the topic. All faculty members / teacher's council of the department will be the reviewer of the course. Equal weightage will be given to Seminal and Technical writing.
- **DISSERTATION – I:** Third Semester dissertation evaluation as per the Academic guide lines of SUIIT.
- **DISSERTATION – II:** Fourth semester or final dissertation and student will be allowed only if after successful completion of third semester project evaluation and the evaluation will be as per the Academic guide lines of SUIIT.

Semester – I						
Code	**Course Title**	**Category**	**L**	**P**	**T**	**Credits**
CS 611	Mathematical Foundations of Computer Science	Foundation Course	4	0	0	**4**
CS 612	Advanced Data Structures and Algorithms	Core Course	4	0	0	**3**
CS 613	Advanced Programming Languages	Core Course	3	0	1	**3**
XX XXXX	Elective –I	Professional Elective	3	0	1	**3**
XX XXXX	Elective –II	Professional Elective	3	0	1	**3**
CS 614	Open source lab-I	Core Course	0	3	0	**2**
CS 615	Advanced Programming Languages lab.	Core Course	0	3	0	**2**
CS 616	Seminar & Technical Writing-I	Technical Seminar	-	-	-	**2**
MOC 617	Cloud Computing (MOOCs-1)	MOOC	3	0	0	**3**
					Total Credit:	**25**

MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE								
Course Code	**CS 611**	**L-P-T-Cr.:**	**4**	**0**	**0**	**4**	**Semester:**	**I**
Category:	Foundation Course							
Prerequisite:	None							
Objective:	Foundations like Logic, Algebraic Structure, Graph Theory and Combinatory, Linear algebra, Number theory and intro to cryptography.							

CO1	Remember and understand the basic concepts/Principles of Mathematical foundations of computer science.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: FOUNDATIONS (10 HOURS)

Logic, Propositional calculus, Equivalences, Predicates and Quantifiers, Nested Quantifiers, Methods of Proof. Functions, Proof Strategy, Mathematical Induction, Recursive Definition and Structural Induction.

Algebraic structures: Semi-groups, Monoids, Groups, cyclic groups, permutation groups, Normal subgroups, group isomorphism's, Rings Fields Finite fields Applications in computer science.

UNIT – II: GRAPH THEORY AND COMBINATORIES (10 HOURS)

Basic Counting Techniques, The Basics of Counting, The Pigeonhole Principle, Permutation and Combinations, Binomial Coefficients, Recurrence Relations, Solving Recurrence Relations. Divide-and-Conquer Algorithms, Recurrence Relations, Generating Functions, Inclusion Exclusion, Applications of Inclusion-Exclusion.

Introduction to Graphs: Graph Terminology. Representing Graph and Graph Isomorphism; Connectivity, Eulerian and Hamiltonian Paths, planarity and graph colouring applications to Network and Maximum flow problems. Spanning Trees, Minimum Spanning Trees, graph algorithms.

UNIT – III: LINEAR ALGEBRA (10 HOURS)

Matrix Algebra, Matrix inverses, System of linear equations, rank, Gaussian elimination, Introduction to vector spaces and linear transformations., Cayley Hamilton theorem, Eigen vectors and Eigen values diagonalisation of matrices. Canonical forms .Singular Value decompositions methods for computing eigenvalues.

Space coordinates: Vectors (addition and Scalar multiplication), Dot product, Application to Geometry, Vector Space, Subspaces, Span of a set, More about sub space, Linear Dependence, Independence: Dimension and Basis, Linear transformation, Matrix representation of Linear transformation, Gram Schmidt Ortho-normalization.

UNIT – IV: NUMBER THEORY AND CRYPTOGRAPHY (10 HOURS)

Basics of Number Theory, Introduction to Cryptography, An overview of Encryption Techniques, Operations used by Encryption algorithms, Symmetric cryptography.

Data encryption standard, International data encryption Algorithm, RC ciphers, Public Key algorithms, The RSA Algorithm, Pretty good privacy, One way Hashing.

TEXT BOOKS:

1. Discrete and Combinatorial Mathematics (An applied Introduction) - *Ralph P. Grimaldi& B.V. Ramana*, 5th edition (PEARSON Education).
2. Number Theory -*David Burton*
3. Cryptography -*D R Stinson*: A CRC press company
4. Linear algebra -*Hoffmann and Kunje* (PHI)

REFERENCE BOOKS:

1. Discrete Mathematics and Its Applications -*Kenneth H. Rosen*. TMH
2. Discrete Mathematics for Computer Scientist and Mathematicians -*Joe L. Mott, Abraham Kandel and Theodore P. Baker*. PHI
3. Discrete Mathematical Structures with Applications to Computer Science - *J. P. Tremblay & R. Manohar*. McGraw-Hill Book Company.
4. The Art of Computer Programming (Volume - 1) - *Knuth*. Narossa publications.
5. Schuam's Outline for Linear algebra -*S Lipschutz* (Tata McGraw-Hill)

Course Outcome: On successful completion of the course the student will be able to:

- Ability to apply mathematical logic to solve problems.
- Understand sets, relations, functions, and discrete structures.
- Able to use logical notation to define and reason about fundamental mathematical concepts such as sets, relations, and functions.
- Able to formulate problems and solve recurrence relations.
- Able to model and solve real-world problems using graphs and trees.

WEB REFERENCES

1. http://nptel.ac.in/courses/106106094/
2. http://nptel.ac.in/courses/106103015/
3. http://nptel.ac.in/courses/106103015/3

ADVANCED DATA STRUCTURE & ALGORITHM								
Course Code	**CS 612**	**L-P-T-Cr.:**	**4**	**0**	**0**	**3**	**Semester:**	**I**

Category:	Core Course
Prerequisite:	Data Structure Basic
Objective:	• Design and analyze programming problem statements. • Choose appropriate data structures and algorithms, understand the ADT/libraries, and use it to design algorithms for a specific problem. • Understand the necessary mathematical abstraction to solve problems. • Come up with analysis of efficiency and proofs of correctness. • Comprehend and select algorithm design approaches in a problem specific manner.

CO1	Remember and understand the basic concepts/principles of advanced data structure & algorithm.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION (10 Hours)

Review of Data Preliminary Structures: Stack, Queue, Linked lists, binary tree and graph. Time complexity, Asymtotic Analysis: complexity-notations, Omega notation and Theta notation, Big O notation, Divide and conquer. Binary search, Quick sort, Merge sort. Master method for recurrence relation, Hashing, B and B + tree, AVL tree.

UNIT –II: GREEDY METHOD AND DYNAMIC PROGRAMMING (10 Hours)

Greedy Method: Knapsack problem, Job sequencing with deadlines, Minimum cost spanning trees, Single source shortest path problem. Dynamic Programming: General method, applications-Strassen's Matrix chain multiplication, sum of subsets problem.

UNIT –III: BRANCH & BOUND AND ONLINE ALGORITHM (10 Hours)

Branch and Bound: General method (Backtracking), N-queen problem, graph coloring, travelling salesman problem. Online Algorithm: Competitive Analysis, Deterministic Algorithms, Randomized Algorithms, Optimum Offline Algorithms, Case Studies – Ski Rental Problem, List Update Problem.

UNIT –IV: APPROXIMATION ALGORITHM AND NP CLASS PROBLEM (10) Hours)

Approximation Algorithms: Basic Concepts, Bounds, Polynomial Time Approximation. Schemes, Bin Packing Problem. NP-Hard and NP-Complete classes, Cook's theorem. Introduction to Beyond NP-Class.

TEXT BOOKS:

1. Introduction to Algorithms, 2nd Edition, T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, PHI Pvt. Ltd. Pearson Education.

REFERENCE BOOKS:

1. Design and Analysis of algorithms, Aho,UllmanandHopcroft, Pearson Education.
2. Computer Algorithms, E.Horowitz, S.Sahani and S.Rajasekharan, Galgotia Publishers pvt. Limited.
3. Algorithms, Robert Sedgewick, Addison- Wesley.
4. Data structure using Java, Sahani.

5. Online Computation and Competitive Analysis - A. Borodin and R. El-Yaniv, Cambridge Univ. Press,1998.
6. Approximation Algorithms - Vijay V. Vazirani, Springer Verlag, 2003.

WEB REFERENCES

1. Approximation Algorithms - Vijay V. Vazirani, Springer Verlag, 2003.
2. http://nptel.ac.in/courses/106101060/

ADVANCED PROGRAMMING LANGUAGES								
Course Code	**CS 613**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	**I**

Category:	Core Course
Prerequisite:	Object oriented Programming Languages, Java Programming
Objective:	Students will learn advanced concept.

CO1	Remember and understand the basic concepts/Principles of advanced programming languages.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: (12Hrs)

Basic features of Python-Interactive execution, comments, types, variables, operators, expressions, Statements-assignment, input, print, Control flow-Conditionals, Loops, break statement, continue statement, pass statement, Functions, definition, call, scope and lifetime of variables, keyword arguments, default parameter values, variable length arguments, recursive functions, Functional programming-mapping, filtering and reduction, Lambda functions, Scope, namespaces and modules-import statement, creating own modules, avoiding namespace collisions when importing modules, module reload, LEBG rule, dir( ) function, iterators and generators, Sequences-Strings, Lists and Tuples-basic operations and functions, iterating over sequences, List comprehensions, Packing and Unpacking of Sequences, Sets and Dictionaries- operations, regular expressions, Python program examples.

UNIT – II: (12Hrs)

Files-operations-opening, reading, writing, closing, filepositions, file names and paths, functions for accessing and manipulating files and directories on disk, os module, Exceptions – raising and handling exceptions, try/except statements, finally clause, standard exceptions, Object oriented programming-classes, constructors, objects, class variables, class methods, static methods, Inheritance-is-a relationship, composition, polymorphism, overriding, multiple inheritance, abstact classes, multithreaded programming, time and calendar modules,Python program examples.

UNIT – III: (12Hrs)

Network Programming-Sockets, Socket addresses, Connection-oriented and Connectionless Sockets, socket module, urllibmodule, Socket object methods, Client/Server applications (TCP/IPand UDP/IP), Socketserver module, handling multiple clients, Client side scripting-Transferring files-FTP, ftplibmodule, ftplib. FTP class methods, sending and receiving emails- smtplibmodule, smtplib. SMTP class methods, poplib module, poplib.POP3 methods, Python program examples.

UNIT – IV: (12Hrs)

Database Programming-SQL Databases, SQLite, sqlite3 module, connect function( ), DB-API 2.0 Connection object methods, Cursor object Attributes and methods, creating Database applications in

Python, Web programming-Simple web client, urllib, urlparsemodules, Server side scripting-Building CGI applications-Setting up a web server, Creating the form page, Generating the results page, Saving state information in CGI Scripts, HTTP Cookies, Creating a cookie, Using cookies in CGI scripts, Handling cookies with urllib2 module, cgi module.

TEXT BOOK:

1. Learning Python, Fabrizio Romano, PACKT publishing.
2. Python for Everybody: Exploring Data in Python 3, Charles Severance, Shroff Publishers.
3. Introduction to Computation and Programming using Python, 2nd edition, John V. Guttag, MIT Press

REFERENCE BOOK:

1. Programming in Python 3, Mark Summerfield, Pearsons
2. Learn Python 3 the Hard Way, Zed A.Shaw, Pearson Education

WEB REFERENCES

1. http://nptel.ac.in/courses/106106147/
2. http://nptel.ac.in/courses/106105084/28
3. http://nptel.ac.in/courses/106105084/11

OPEN SOURCE LAB								
Course Code	**CS 614**	**L-P-T-Cr.:**	**0**	**3**	**0**	**2**	**Semester:**	**I**
Category:	Laboratory Course							

Prerequisite:	Basic idea about Linux operating systems, web technology, database management systems.
Objective:	Learn various open source tools for research work

CO1	Remember and understand the basic concepts/Principles of open source lab.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

LIST OF TOPICS FOR EXPERIMENTS:

1. Linux Commands – Introduction to various distros, understanding Linux filesystem, package management System, shell commands
2. vi editor – using a console based editor
3. grep
4. sed
5. pipes & filters
6. shell scripting
7. php – Introduction to web servers, Server side scripting using PHP, simple applications
8. php-mysql – Introduction to MySQL, database connectivity and design front-ends using PHP
9. R – open source statistics
10. jquery -javascript framework

Consists of 10 labs exercises – 2 periods each (3 x 2 = 6 hour classes, Total 60 Hours)

ADVANCED PROGRAMMING LANGUAGE LAB								
Course Code	**CS 615**	**L-P-T-Cr.:**	**0**	**3**	**0**	**2**	**Semester:**	**I**
Category:	Laboratory Course							
Prerequisite:	Concepts Advanced java programming and HTML							
Objective:	• To learn how to use lists, tuples, and dictionaries in Python programs. • To learn how to identify Python object types. • To learn how to use indexing and slicing to access data in Python programs. • To define the structure and components of a Python program. • To learn how to write loops and decision statements in Python. • To learn how to write functions and pass arguments in Python.							

CO1	Remember and understand the basic concepts/Principles of advanced programming language lab.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

LIST OF TOPICS FOR EXPERIMENTS:

- Python Basics – variables, strings, numbers, math operators, built-in functions, lists – indexing, slicing, methods, tuples, dictionaries, user input, conditionals, functions, file handeling – reading, processing, appending.
- Python modules, libraries, dates & times, error handling
- Building Python applications:
  - Interactive Dictionaries
  - Data analysis using pandas
  - Using Numpy
  - Web Application
  - Graphical User Interface with Tiknter
  - Webscraping
  - Textmining
  - Basic Machine Learning

Semester – II						
Code	**Course Title**	**Category**	**L**	**P**	**T**	**Credits**
CS 621	Cryptography and Network Security	Core Course	4	0	0	**4**
CS 622	Data Warehousing and Data Mining	Core Course	4	0	0	**4**
XX XXXX	Elective –III	Professional Elective	3	0	0	**3**
XX XXXX	Elective –IV	Professional Elective	3	0	1	**3**
XX XXXX	Elective –V	Professional Elective	3	0	0	**3**
CS 623	Network programming lab.	Core Course	0	3	0	**2**
CS 624	Seminar & Technical Writing-II	Technical Seminar	-	-	-	**2**
MOC 625	Data Science for Engineers (MOOCs-2)	MOOC	3	0	0	**3**
					Total Credit:	**24**

CRYPTOGRAPHY AND NETWORK SECURITY								
Course Code	**CS 621**	**L-P-T-Cr.:**	**4**	**0**	**0**	**4**	**Semester:**	**II**
Category:	Core Course							
Prerequisite:	Number Theory and Cryptography							
Objectives:	• Explain the objectives of information security • Explain the importance and application of each of confidentiality, integrity, authentication and availability • Understand various cryptographic algorithms. • Understand the basic categories of threats to computers and networks • Describe public-key cryptosystem. • Describe the enhancements made to lPv4 by IPSec • Understand Intrusions and intrusion detection • Discuss the fundamental ideas of public-key cryptography. • Generate and distribute a PGP key pair and use the PGP package to send an encrypted e-mail message. • Discuss Web security and Firewalls							

CO1	Remember and understand the basic concepts/Principles of cryptography and network security.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: Classical Encryption Techniques (08 Hours)

Introduction: Cryptography, cryptanalysis, Security attacks, services & mechanisms, Symmetric Cipher Model, Substitution Techniques, Transportation Techniques, Cyber threats and their defense (Phishing Defensive measures), web based attacks, SQL injection & Defense techniques, Buffer overflow & format string vulnerabilities, TCP session hijacking (ARP attacks, route table modification) UDP hijacking (man-in-the-middle attacks).

UNIT –II: Block Ciphers, Symmetric Key Cryptography & Asymmetric Key Cryptography (12 Hours)

Traditional Block Cipher Structure, DES,Triple DES, Block Cipher Design Principles, AES-Structure, Transformation functions, Key Expansion, Blowfish, IDEA, Block Cipher Modes of Operations. **Public Key Cryptography**: Principles, public key cryptography algorithms, RSA Algorithms, Diffie Hellman Key Exchange, Elliptic Curve Cryptography

UNIT –III: Cryptographic Hash Functions & Digital Signatures (12 Hours)

Message authentication and Hash Functions, Authentication Requirements and Functions, Message Authentication, Hash Functions and MACs Hash and MAC Algorithms SHA-512, HMAC, Digital Signatures, NIST Digital Signature Algorithm. Key management & distribution. User Authentication: Remote user authentication principles, Kerberos

UNIT –IV: User Authentication, Transport Layer Security & Email Security IP Security &

Intrusion Detection Systems **(08 Hours)**

Transport Level Security: Web Security Requirements, Secure Socket Layer (SSL) and Transport Layer Security (TLS), Secure Shell(SSH) **Electronic Mail Security**: Pretty Good Privacy (PGP) and S/MIME. **IP Security:** IP Security Overview, IP Security Architecture, Authentication Header, Encapsulating Security Payload, Combining Security Associations and Key Management.Firewalls:Need for Fire wall,Types of Firewall , Firewall Designing principle

TEXT BOOKS:

1. Cryptography and Network Security - Principles and Practice: William Stallings, Pearson Education, 6th Edition
2. Introduction to Computer Networks & Cyber Security, ChwanHwa Wu, J.David Irwin, CRC press
3. Hack Proofing your Network, Russell, Kaminsky, Forest Puppy, Wiley Dreamtech.

REFERENCE BOOKS

1. Cryptography and Network Security: C K Shyamala, N Harini, Dr T R Padmanabhan, Wiley India, 1 st Edition.
2. Cryptography and Network Security :ForouzanMukhopadhyay, McGraw Hill, 3rd Edition
3. Information Security, Principles, and Practice: Mark Stamp, Wiley India.
4. Principles of Computer Security: WM. Arthur Conklin, Greg White, TMH
5. Introduction to Network Security: Neal Krawetz, Cengage Learning
6. Network Security and Cryptography: Bernard Menezes, Cengage Learning

WEB REFERENCES

1. http://nptel.ac.in/courses/106105031/
2. https://onlinecourses.nptel.ac.in/noc18_cs07/preview

DATA WAREHOUSING AND DATA MINING								
Course Code	**CS 622**	**L-P-T-Cr.:**	**4**	**0**	**0**	**4**	**Semester:**	**II**
Category:	Core Course							
Prerequisite:	Data Structure and Algorithm, Linear Algebra, Basics of Web programming							
Objectives:	• This course deals with evolving multi-dimensional intelligent model from a typical system, representation of multi-dimensional data for a data warehouse. • Discovering the knowledge imbibed in the high dimensional system. • Finding the hidden interesting patterns in data, and gives the idea to evaluate various mining techniques on complex data objects.							

CO1	Remember and understand the basic concepts/Principles of data warehousing and data mining.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: **12 hours**

Introduction to Data Mining: What is Data Mining, Motivating Challenges, The origins of Data Mining, Data Mining Tasks. Data: Types of Data, Data quality, Data Preprocessing, Measures of Similarity and Dissimilarity.

Data Warehouse and OLAP Technology for Data Mining: What is a Data Warehouse? Multi-Dimensional Data Model, Data Warehouse Architecture, Data Warehouse Implementation, Development of Data Cube Technology, Data Warehousing to Data Mining.

UNIT – II: **10 hours**

Classification: Basic Concepts, Decision Trees, and Model Evaluation Preliminaries, General Approach to solving a classification Problem, Decision Tree, Induction, Issues Regarding Classification and Prediction Model Over fitting, Evaluating the performance of a classifier.

Classification: Alternate Techniques Rule-based Classifier, Nearest-Neighbor Classifiers, Bayesian Classifiers, Support vector Machines, Classification by Backpropagation, Prediction, and Classifier Accuracy.

UNIT – III: **10 hours**

Association Analysis: Basic Concepts and Algorithms Problem Definition, Frequent Itemset Generation, Compact Representation of Frequent Itemsets, Alternative Methods for generating Frequent Itemsets, Evaluation of Association Patterns

Cluster Analysis: Basic Concepts and Algorithms Overview, K-Means, Agglomerative Hierarchical Clustering, DBSCAN, Cluster Evaluation

UNIT – IV: **08 hours**

Mining complex data objects, Spatial databases, temporal databases, Multimedia databases, Time series and Sequence data; Text Mining –Graph mining-web mining-Application and trends in data mining.

TEXT BOOKS

1. Jiawei Han and MichelineKamber, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, third edition2011, ISBN: 1558604898.
2. Alex Berson and Stephen J. Smith, "Data Warehousing, Data Mining & OLAP", TataMcGraw Hill Edition, Tenth Reprint 2007.
3. G. K. Gupta, "Introduction to Data Min Data Mining with Case Studies", Easter Economy Edition, Prentice Hall of India, 2006

REFERENCE BOOKS

1. Data Mining Techniques–Arun K Pujari, University Press
2. Mehmedkantardzic,"Data mining concepts, models, methods, and lgorithms", Wiley Interscience, 2003.
3. Ian Witten, Eibe Frank, Data Mining; Practical Machine Learning Tools and Techniques, third edition, Morgan Kaufmann, 2011.
4. George M Marakas, Modern Data Warehousing, Mining and Visualization, Prentice Hall, 2003.

Other References: (Web)

1. http://www.data-miners.com/

NETWORK PROGRAMMING LAB

Course Code	CS 623	L-P-T-Cr.:	0	3	0	2	Semester:	II
Category:	Laboratory Course							
Prerequisite:	Data Communications and Computer Networks							
Objectives:	1. Learn to write TCL script, understand linking of nodes, agents, and to connect application protocol on them. 2. Develop wired and wireless topology along with featured of NS2 like using Xgraph and NAM. 3. Grep command of unix is used to extract features from the trace file 4. Understanding socket programming and Inter-process Communication.							

CO1	Remember and understand the basic concepts/Principles of network programming lab.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

LIST OF TOPICS FOR EXPERIMENTS

1. Unix Process and Signals: fork, vfork, exit, wait, waitpid, exec, system, Signal functions, kill and raise functions, alarm, pause functions, abort, sleep functions.
2. Unix Inter-process Communication (IPCs): Files and record Locking, FIFOs, streams and messages, message queues, semaphores and shared memory, Socket Programming.
3. Few interactive experiments related to router, cabling, H/W and software configuration for computer communication.
4. Some Network protocols simulation using NetSim, NS2, or any other protocol simulators for:
   a. Analyzing number of transmitting nodes vs. collision count, mean delay for Ethernet LAN.
   b. Analyzing bus vs. star-switch with respect to number of collisions (for a fixed number of transmitting nodes) for Ethernet LAN
   c. Analyzing performance of token ring with number of nodes vs. response time, mean delay.
   d. Comparing the throughput and normalized throughput for token ring and token bus for different transmitting nodes.
   e. Comparing the CSMA/CD vs. CSMA/CA protocols (for a fixed number of transmitting nodes).
   f. Analyzing the difference between unicast and broadcast transmission (for a fixed number of transmitting nodes).
   g. Verification of stop-and-wait protocol, Go-back-N protocol, Selective repeat protocol, distance vector routing algorithm, state routing algorithm.
5. Socket programming.

WEB REFERENCES:

1. https://www.isi.edu/nsnam/ns/
2. https://www.javatpoint.com/socket-programming

Elective Pool (for Elective-I to VII)	
CS 6E01	Artificial Intelligence
CS 6E02	Information retrieval and web search
CS 6E03	Pattern Recognition
CS 6E04	Advanced Computer Networking
CS 6E05	Advanced Databases
CS 6E06	Advanced Computer Architecture
CS 6E07	Mobile Computing
CS 6E08	Principles of Programming Languages
CS 6E09	Intellectual Property Rights and Cyber Laws
CS 6E10	Formal Languages and Automata Theory
CS 6E11	Image Processing
CS 6E12	High Performance Computing
CS 6E13	Internet of Things
CS 6E14	Storage Area Networks
CS 6E15	Game Theory
CS 6E16	Software define network
CS 6E17	Machine Learning
CS 6E18	Big Data Analytics
CS 6E19	Cloud Computing
CS 6E20	Soft Computing
CS 6E21	Real time system
CS 6E22	Software Engineering
CS 6E23	Wireless Sensor Network & Applications
CS 6E24	Semantic Web and Social Networking
CS 6E25	Advanced Operating Systems
CS 6E26	Software Project Management
CS 6E27	Parallel algorithms
CS 6E28	Probability &Stochastic Process
CS 6E29	Time Series Analysis
CS 6E30	Computer Based Numerical and Statistical Methods

ARTIFICIAL INTELLIGENCE								
Course Code	**CS 6E01**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Concepts of Data structures and Design and Analysis of algorithms							
Objectives:	• To learn the difference between optimal reasoning VS human like reasoning. • To understand the notions of state space representation and heuristic search. • To learn different knowledge representation techniques. • To understand the applications of AI: namely Game playing, Theorem Proving. Expert systems, machine learning and Natural language Processing.							

CO1	Remember and understand the basic concepts/Principles of artificial intelligence.

CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: **(10 Hours)**

Introduction to Artificial Intelligence, AI Problems, AI Techniques,Problems ,Problem Space and Search, Defining the problem as a state space search, Production system, Problem characteristics, **Heuristic search Technologies:** Generate and Test, Hill Climbing, Best First Search, Problem Reduction, means-end-analysis, optimal and A*,AND-OR Graphs, AO* Algorithms.

UNIT – II: **(12 Hours)**

Representation Knowledge using Predicate Logic, Representing simple facts in logic, Representing Instance and ISA relationships, Computable functions and Predicates, Resolution, Representing Knowledge using Rules, Forward Vs Backward Reasoning, Matching , Control Knowledge, , Weak slot and Filter structures, Semantic nets, Frames.

UNIT – III: **(12 Hours)**

Strong slot and Filter structures, Conceptual Dependencies, Scripts. Introduction to Non monotonic reasoning ,Logics for Non monotonic reasoning, Implementation : Depth First Search, Dependency-Directed Back Tracking, Justification based Truth Maintenance Logic based Truth Maintenance systems, Statistical Reasoning, Probability and Bayes Theorem, Certainty factors, Rule based Systems, Bayesian Networks, Dempster-Shaffer Theory.

UNIT – IV: **(12 Hours)**

Minmax search, alpha-beta cutoffs, Planning system, Goal stack planning, Hierarchical Planning, Natural Language Processing., Syntactic Analysis, Semantic Analysis, Discuses and Pragmatic Processing. Introduction and Fundamentals of Artificial Neural Networks, Biological Prototype, Artificial Neuron, Single Layer Artificial Neural Networks, Multilayer Artificial Neural Networks, Training of Artificial Neural Networks

TEXT BOOKS

1. Elaine Rich, Kevin Knight and ShivashankarB . Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
2. Neural Computing: Theory and practice- Waserman.

REFERENCE BOOKS:

1. Artificial Intelligence Structures and Strategies complex problem solving-George F. Lugar Pearson Education
2. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
3. Dan W. Patterson, Artificial Intelligence and Expert Systems, PHI.
4. Neural Networks: A Comprehensive Foundation 2/e- Symen Pearson Education.

WEB REFERENCES

1. http://nptel.ac.in/courses/106106126/
2. http://nptel.ac.in/courses/106105079/

INFORMATION RETRIEVAL AND WEB SEARCH								
Course Code	**CS 6E02**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Data Structure and Algorithm, Linear Algebra, Basics of Web programming							
Objectives:	This course will cover: • Traditional material, as well as recent advances in Information Retrieval (IR). • The study of indexing, processing, and querying textual data. • Basic retrieval models, algorithms, and IR system implementations.							

CO1	Remember and understand the basic concepts/Principles of information retrieval and web search.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION **(8 Hours)**

Introduction to course: Discussion of issues in search, Introduction to Information Retrieval. Inverted indices and Boolean queries. Query optimization. The nature of unstructured and semi-structured text. Course administrivia.
The term vocabulary and postings lists. Text encoding: tokenization, stemming, lemmatization, stop words, phrases. Optimizing indices with skip lists. Proximity and phrase queries. Positional indices.

UNIT –II: INDEX CONSTRUCTION AND SCORING (10 Hours)

Index construction. Postings size estimation, sort-based indexing, dynamic indexing, positional indexes, n-gram indexes, distributed indexing, real-world issues.
Index compression: lexicon compression and postings lists compression. Gap encoding, gamma codes, Zipf's Law, variable-byte encoding. Blocking. Extreme compression.
Dictionaries and tolerant retrieval. Dictionary data structures. Wild-card queries, permuterm indices, n-gram indices. Spelling correction and synonyms: edit distance, soundex, language detection.
Scoring, term weighting, and the vector space model. Parametric or fielded search. Document zones. The vector space retrieval model. TF/IDF weighting. The cosine measure. Scoring documents.

UNIT –III: COMPUTING SCORES AND RESULTS SUMMARIES (8 Hours)

Computing scores in a complete search system: Components of an IR system. Efficient vector space scoring. Nearest neighbor techniques, reduced dimensionality approximations, random projection.
Results summaries: static and dynamic. Evaluating search engines. User happiness, precision, recall, F-measure. Creating test collections: kappa measure, inter judge agreement. Relevance, approximate vector retrieval
Probabilistic IR. Binary Independence Model.

UNIT –IV: CLASSIFICATION AND LEARNING & WEB SEARCH AND LINK ANALYSIS (14 Hours)

CLASSIFICATION: Introduction to text classification. Naive Bayes models. Spam filtering. Probabilistic IR. K Nearest Neighbors, Decision boundaries, Vector space classification using centroids. Support vector machine classifiers. Kernel Function. Evaluation of classification. Micro- and macro-averaging. Learning rankings.
CLUSTERING: Introduction to the problem. Partitioning methods: k-means clustering; Hierarchical clustering. Learning to rank. Latent semantic indexing (LSI). Applications to clustering and to information retrieval.
Web search overview, web structure, the user, paid placement, search engine optimization/spam. Web size measurement.
Link analysis, Crawling and web indexes. Near-duplicate detection.

TEXT BOOKS:

1. Introduction to Information Retrieval, Christopher D. Manning, PrabhakarRaghavan, HinrichSchütze, Cambridge University Press.

REFERENCE BOOKS:

1. Readings in Information Retrieval, K.Sparck Jones and P. Willet, Morgan Kaufmann.
2. Modern Information Retrieval, Ricardo BaezaYates and BerthierRibeiroNeto, Ricardo Baeza-Yates and BerthierRibeiro-Neto Addison-Wesley.

PATTERN RECOGNITION								
Course Code	**CS 6E03**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Basic of Algorithm, Linear Algebra, Vector Space, Probability and Statistics							
Objectives:	• To know about supervised and unsupervised Learning. • To study about feature extraction and structural pattern recognition. • To explore different classification models. • To learn about fuzzy pattern classifiers and perception.							

CO1	Remember and understand the basic concepts/Principles of pattern recognition.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION AND STASTICAL PATTERN RECOGNITION (10 Hours)
Introduction and mathematical preliminaries - What is pattern recognition?, Clustering vs.

Classification; Applications; Linear Algebra, vector spaces, probability theory, estimation techniques.

Classification: Bayes decision rule, Error probability, Error rate, Minimum distance classifier, Mahalanobis distance; K-NN Classifier, Linear discriminant functions and Non-linear decision boundaries.

UNIT –II: DIMENTION REDUCTION AND CLUSTER ANALYSIS (10 Hours)

Fisher's LDA, Single and Multilayer perceptron, training set and test sets, standardization and normalization.

Clustering: Different distance functions and similarity measures, Sum of Squared Error Technique, Minimum within cluster distance criterion, K-means clustering, single linkage and complete linkage clustering, , existence of unique clusters or no clusters

UNIT –III: FEATURE SELECTION AND FEATURE EXTRACTION (10 Hours)

Feature selection: Problem statement and Uses, Probabilistic reparability based criterion functions, interclass distance based criterion functions, Branch and bound algorithm, sequential forward/backward selection algorithms, (l, r) algorithm.

Feature Extraction: PCA, Kernel PCA.

UNIT –IV: ADVANCES IN PATTERN RECOGNITION (10 Hours)

Recent advances in PR: Structural PR, SVMs, FCM, Soft-computing and Neuro-fuzzy

TEXT BOOKS:

1. R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, JohnWiley, 2001.
2. 3. S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009.

REFERENCE BOOKS:

1. Statistical pattern Recognition; K. Fukunaga; Academic Press, 2000.
2. M. Narasimha Murthy and V.Susheela Devi, ―Pattern Recognition‖, Springer 2011.
3. Robert J.Schalkoff, ―Pattern Recognition Statistical, Structural and Neural Approaches‖, John Wiley & Sons Inc., New York, 1992.
4. C.M.Bishop,―Pattern Recognition and Machine Learning‖, Springer, 2006.
5. Andrew Webb, ―Stastical Pattern Recognition‖, Arnold publishers, London, 1999.

WEB REFERENCES

1. http://www.ph.tn.tudelft.nl/PRInfo/
2. http://kdd.ics.uci.edu/
3. http://morden.csee.usf.edu/nnc/index1.html
4. http://www.iapr.org/

ADVANCED COMPUTING NETWORKING								
Course Code	**CS 6E04**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Basic of Computer network and Cryptography							
Objectives:	• Internet Architecture: Advanced concepts of TCP/IP protocols • Wireless Networks, Cellular networks • Advanced concepts of networks							

CO1	Remember and understand the basic concepts/Principles of advanced computing networking.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: (08 Hours)

The internet architecture, Access Networks, The network Core, Peer-to-Peer Networks, ContentDistribution Networks, Delay Tolerant Networks, Circuit Switching vs. Packet switching, Packetswitching Delays and congestion, Client/Server and Peer-to-Peer Architectures, MAC and LLC,Virtual LAN, Asynchronous Transfer Mode (ATM)

UNIT –II: (12 Hours)

Network Address Translator, Internet Control Message Protocol, SNMP, CIDR, IPv6, Routing Protocol Basics in advanced networks, Routing Information Protocol (RIP), Interior Gateway Routing Protocol (IGRP), Switching Services, Spanning Tree Protocol (STP), Standard Network Management Protocol.

TCP and Mobile TCP, TCP Tahoe and TCP Reno, High speed TCP, Coexistence of UDP and TCP flows, HTTP and HTTPS, FTP and SFTP, Domain Name Service, TCP and UDP sockets

UNIT –III: (10 Hours)

Introduction to traffic Engineering, Requirement Definition for Traffic Engineering, Traffic Sizing, Traffic Characteristics, Delay Analysis, Connectivity and Availability, Introduction to Multimedia Services, Explaining Transmission of Multimedia over the Internet. Introduction, Wireless Links and Network Characteristics, CDMA, WiFi: 802.11, Wireless LANs, The 802.11 Architecture, The 802.11 MAC Protocol, The IEEE 802.11 Frame, Mobility in the Same IP Subnet, Advanced Features in 802.11, Personal Area Networks: Bluetooth and Zigbee, Cellular Internet Access, An Overview of Cellular Network Architecture, 3G Cellular Data Networks: Extending the Internet to Cellular Subscribers, On to 4G: LTE, Mobility Management: Principles, Addressing, Routing to a Mobile Node, Mobile IP ,Managing Mobility in Cellular Networks, Routing Calls to a Mobile User, Handoffs in GSM, Wireless and Mobility: Impact on Higher-Layer Protocols

UNIT –IV: (10 Hours)

Explaining IP Multicasting, VOIP, Unified Communication, Virtual Networking, Data center Networking, Introduction to Optical Networking, SONET /SDH Standard, Next generation cellular networks, Secure Socket Layer, IP Sec, TLS, Kerberos, Domain name system Protection.

TEXT BOOKS:

1. Computer Networking: A Top-Down Approach, 6/e, James F. Kurose and Keith W. Ross, Pearson Education, 2012.
2. Larry L. Peterson and Bruce S. Davie, Computer Networks: A systems approach, Morgan Kaufman, 5th Edition, 2012
3. Data Communications and Networking, *Behrouz A. Forouzan*, Fourth Edition, Tata McGraw Hill
4. High Speed Networks and Internets – Performance and Quality of Service, *William Stallings,* Second Edition, Pearson Education.
5. Top-Down Network Design, *Priscilla Oppenheimer,* Second Edition, Pearson Education (CISCO Press)

REFERENCE BOOKS:

1. Advance Computer Network, By DayanandAmbawade, Dr. Deven shah, Prof. MahendraMehra, Wiley India
2. CCNA Intro – Study Guide – Todd Lammle, Sybex
3. Computer Networks by Mayank Dave, Cengage.
4. Guide to Networking Essentials, Greg Tomsho, Ed Tittel, David Johnson, Fifth Edition, Thomson.
5. Computer Networks, Andrew S. Tanenbaum, Fourth Edition, Prentice Hall.
6. An Engineering Approach to Computer Networking, S. Keshav, Pearson Education.
7. Campus Network Design Fundamentals, Diane Teare, Catherine Paquet, Pearson Education (CISCO Press
8. Computer Communications Networks, Mir, Pearson Education.
9. Chwan-Hwa (John) Wu, J. David Irwin, Introduction to computer networks and Cyber Security, CRC press, Taylor & Francis Group, 2014
10. Andrew S. Tanenbaum, David J. Wetherall, Computer Networks, Pearson, 5th Edition, 2014
11. G. Wright and W. Stevens, TCP/IP Illustrated, Volume 1 and Volume 2, Addison-Wesley, 1996

WEB REFERENCES

1. http://nptel.ac.in/courses/106105081/1

2. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Computer%20networks/New_index1.html

ADVANCED DATABASE								
Course Code	**CS 6E05**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	DBMS, Computer Networks							
Objectives:	• To review the concepts of database architecture, schema and data models. • Revisiting the theory of normalization and various normal forms. • To provide a strong foundation in advanced database concepts from an industry perspective. • To covers advanced data modeling concepts like OOD Modeling and ORD Modeling. • To learn query processing and transaction management concepts for object-relational database and distributed database.							

CO1	Remember and understand the basic concepts/Principles of advanced database.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: PARALLEL AND DISTRIBUTED DATABASES (08 Hours)

Inter and Intra Query Parallelism – Architecture – Query evaluation – Optimization – Distributed Architecture – Storage – Catalog Management – Query Processing - Transactions – Recovery - Large-scale Data Analytics in the Internet Context – Map Reduce Paradigm - run-time system for supporting scalable and fault-tolerant execution - paradigms: PigLatin and Hive and parallel databases versus Map Reduce

UNIT –II: ACTIVE DATABASES, TEMPORAL AND OBJECT DATABASES (14 Hours)

Syntax and Sematics (Starburst, Oracle, DB2) – Taxonomy – Applications – Integrity Management – Workflw Management – Business Rules – Design Principles – Properties – Rule Modularization – Rule

Debugging – IDEA methodology – Open Problems.

Overview – Data types – Associating Facts – Temporal Query Language – TSQL2 – Time Ontology – Language Constructs – Architecture – Temporal Support – Object Database and Change Management – Change of Schema – Implementing Database Updates in O2 – Benchmark Database Updates – Performance Evaluation.

UNIT –III: SPATIAL, TEXT AND MULTIMEDIA DATABASES (08 Hours)

Traditional Indexing Methods (Secondary Keys, Spatial Access Methods) – Text Retrieval – Multimedia Indexing – 1D Time Series – 2d Color images – Sub pattern Matching – Open Issues – Uncertainties

UNIT –IV: COMPLEX QUERIES AND REASONING (10 Hours)

Logic of Query Languages – Relational Calculi – Recursive rules – Syntax and semantics of Data log – Fix point semantics – Implementation Rules and Recursion – Rule rewriting methods – Compilation and Optimization – Recursive Queries in SQL – Open issues.

Introduction to Big data analytics and No-SQL

TEXT / REFERENCE BOOKS:

1. Ramakrishnan, Gehrke, "Database Management System", Tata McGraw Hill Publications, Third Edition.
2. Carlo Zaniolo, Stefano Ceri "Advanced Database Systems", Morgan Kauffmann Publishers.
3. VLDB Journal.
4. Elmaski&Navathe -Fundamentals of Database Systems, 4th Edition, Pearson Education
5. Database Systems, Thomas Connolly, Carolyn Begg
6. Raghu Ramakrishnan, "Database Management Systems", Third Edition, McGraw Hill, 2002.

WEB REFERENCES

1. http://video.google.com
2. http://www.blinkvid.com/video
3. http://www.learnerstv.com/course.php?cat=Computers
4. http://www.crazyengineers.com/forum

ADVANCED COMPUTER ARCHITECTURE								
Course Code	**CS 6E06**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Computer Architecture and Organization							
Objectives:	• To identify the key components of a computing system. • To model the parallel programming paradigm. • To gain in-depth knowledge of architecture. • To study different parallel interconnection systems.							

CO1	Remember and understand the basic concepts/Principles of advanced computer architecture.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION TO PARALLEL PROCESSING (10 Hours)

Parallel Processing: Definition, Theory of Parallelism: Parallel Computer Models, Parallelism in Uni-processor computers, Implicit Parallelism vs. explicit parallelism, conditions of parallelism: Data and Resource Dependencies, Control Dependence, Resource dependence, Bernstein‘s condition, Hardware and software parallelism, Levels of parallelism. Multiprocessors and multicomputers, Multivector and SIMD computers, PRAM and VLSI models, Software Parallelism, Hardware Parallelism, Amdahl‘s law, Overview of RISC and CISC architecture, System Performance attributes of parallel Computers.

UNIT –II: PIPELINING AND SUPERSCALAR TECHNIQUE (10 Hours)

Linear pipeline processors, Non-linear pipeline processors: Reservation and latency analysis, Collision-free scheduling. Pipelining: Basic concepts of pipelining, Pipeline hazards, Techniques for overcoming or reducing the effects of various hazards, Speedup, efficiency, throughput, How is pipelining implemented?

UNIT–III: INSTRUCTION-LEVEL PARALLELISM AND ITS EXPLOITATION (10 Hours)

Concepts and challenges, Basic compiler techniques for exposing ILP, superscalar, super-pipelined and VLIW processor architectures, array processor, vector processor, symbolic processors, Associative Processor, Systolic architecture. Amdahl’s Law, scalability-isoefficiency function. Dynamic instruction scheduling- Static scheduling-loop unrolling, overcoming data hazards with dynamic scheduling-Tomasulo’s approach, scoreboarding, Dynamic scheduling: Examples and the algorithm, hardware-based speculation, Exploiting ILP using static scheduling

UNIT –IV: INTERCONNECTION NETWORKS AND CACHE ORGANIZATION (10 Hours)

Definition of Network Topologies, Network properties and routing: Permutation, Perfect shuffle-exchange, hypercube routing functions, broadcast-multicast. Classification – Static Connection Network and Dynamic Connection Networks. Factors affecting performance of interconnection network.

Cache memory organization- Memory hierarchy technology, Properties: inclusion, coherence and locality, Cache addressing models, Direct mapping and associative caches, Set-associative and sector caches, cache performance issues. types of cache miss. Techniques to reduce cache misses, cache coherence and synchronization mechanism: The cache coherence problem, snoopy-bus protocol, Directory-based protocol.

TEXT BOOKS:

1. Kai Hwang and Faye A. Briggs, Computer Architecture and Parallel Processing, 1990.
2. John L. Hennessey and David A. Patterson, Computer Architecture: A Quantitative Approach, 3/e, Morgan Kaufmann, 2003.

REFERENCE BOOKS

1. David A. Patterson and John L. Hennessy, Computer Organization and Design, Elsevier.
2. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, McGraw-Hill.
3. Computer Architecture: Parhami, Oxford University Press

WEB REFERENCES

1. http://nptel.ac.in/courses/106105033/
2. http://nptel.ac.in/courses/106102062/

MOBILE COMPUTING								
Course Code	**CS 6E07**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Data communication and Computer Networks							
Objectives:	• To learn emerging techniques in GSM, wireless MAC. • Learn mobile network and transport layer. Learn mobile database, data dissemination and MANAT protocols. • The objective is to be familiar with personal communication services, study global system for mobile communication, learn server-side programming. • Learn case studies of the IRIDIUM and GLOBALSTAR, and quality of services in 3G.							

CO1	Remember and understand the basic concepts/Principles of mobile computing.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: **10 hours**

Introduction to Mobile Communications and Computing: Mobile Computing (MC):Introduction to MC, novel applications, limitations, and architecture.

GSM: Mobile services, System architecture, Radio interface, Protocols, Localization andcalling, Handover, Security, and New data services.

Wireless Medium Access Control : Motivation for a specialized MAC (Hidden and exposed terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA.

UNIT – II: **10 hours**

Mobile Network Layer: Mobile IP (Goals, assumptions, entities and terminology, IP packetdelivery, agent advertisement and discovery, registration, tunneling and encapsulation, Optimizations), Dynamic Host Configuration Protocol (DHCP).

Mobile Transport Layer : Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/fast recovery, Transmission /time-out freezing, Selective retransmission, Transaction oriented TCP.

UNIT – III: **10 hours**

Database Issues: Hoarding techniques, caching invalidation mechanisms, client server computing with adaptation, power-aware and context-aware computing, transactional models, query processing, recovery, and quality of service issues.

Data Dissemination: Communications asymmetry, classification of new data delivery mechanisms, push-based mechanisms, pull-based mechanisms, hybrid mechanisms, selective tuning (indexing)

techniques.

UNIT – IV: **10 hours**

Mobile Ad hoc Networks (MANETs): Overview, Properties of a MANET, spectrum of MANET applications, routing and various routing algorithms, security in MANETs.

Protocols and Tools: Wireless Application Protocol-WAP. (Introduction, protocol architecture, and treatment of protocols of all layers), Bluetooth (User scenarios, physical layer, MAC layer, networking, security, link management) and J2ME.

TEXT BOOKS

1. JochenSchiller,"MobileCommunications",Addison-Wesley.
2. Stojmenovic and Cacute, "Handbook of Wireless Networks and Mobile Computing"

REFERENCE BOOKS:

1. Reza Behravanfar, "Mobile Computing Principles: Designing and Developing Mobile Applications with UML and XML", ISBN: 0521817331, Cambridge University Press.
2. Adelstein, Frank, Gupta, Sandeep KS, Richard III, Golden, Schwiebert, Loren, "Fundamentals of Mobile and Pervasive Computing", McGraw-Hill Professional.
3. Hansmann, Merk, Nicklous, Stober, "Principles of Mobile Computing", Springer.
4. MartynMallick, "Mobile and Wireless Design Essentials", Wiley DreamTech.

Other References: (Web)

- https://onlinecourses.nptel.ac.in/noc16_cs13/preview
- https://www.cse.iitk.ac.in/users/rkg/Talks/mobile_main.pdf

PRINCIPLES OF PROGRAMMING LANGUAGES								
Course Code	**CS 6E08**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							

Prerequisite:	Basic set theory operations
Objective:	Student will learn concepts of Control flow, Subroutine, concurrency control mechanism in contrast with functional programming language.

CO1	Remember and understand the basic concepts/Principles of principles of programming languages.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: (13 Hours)

Introduction: The Art of language design, the programming language spectrum, why study programming languages?, compilation and interpretation, programming environments. Names, scopes, and bindings, the notion of binding time, object lifetime and storage management, static allocation, stack based allocation, heap based allocation, garbage collection, scope rules, implementing, the meaning of names within a scope.

Control Flow: Expression evaluation, structured and unstructured flow, sequencing, selection, iteration, recursion. Data Types : Type systems, type checking, records (structures) and variants (unions), arrays, strings, sets, pointers and recursive types, lists, files and input/output.

UNIT –II: (08 Hours)

Subroutines and Control Abstraction: Review of stack layout, calling sequences, parameter passing, generic subroutines and modules, exception handling, co-routines, events. Data abstraction and object orientation: Object oriented programming, encapsulation and inheritance, initialization and finalization, dynamic method binding, multiple inheritance, object oriented programming revisited.

UNIT –III: (08 Hours)

Functional Languages: Historical origins, functional programming concepts, a review/overview of scheme.

Logic Languages: Logic programming concepts, prolog, logic programming in perspective.

UNIT –IV: (11 Hours)

Concurrency: Background and motivation, concurrent programming fundamentals, implementing synchronization, semaphores, language level mechanisms message passing. Scripting Languages: What is a scripting language? problem domains, scripting the world wide web, innovative features.

TEXT BOOKS:

1. Michael L. Scott, Programming Language Pragmatics, 3/e, Elsevier Inc., 2009.

REFERENCE BOOKS:

1. Friedman, Wand and Haynes, Essentials of Programming Languages, PHI, 1998.
2. Tennant, Principles of Programming Languages, PHI, 1981.

WEB REFERENCES

1. http://nptel.ac.in/courses/106102067/
2. http://nptel.ac.in/courses/106102067/40

INTELLECTUAL PROPERTY RIGHTS AND CYBER LAWS			
Course Code	**CS 6E09**	**L-P-T-Cr.:** **3 0 1 3**	**Semester:**
Category:	Programme Elective Course		
Prerequisite:	None		
Objective:	Both Indian and International intellectual property, cyber laws		

CO1	Remember and understand the basic concepts/Principles of intellectual property rights and cyber laws.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.

CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTON AND CONCEPTUAL FRAMEWORK (10 Hours)

Origin and evolution of IPRs – Conceptual framework of IPRs – Patents, Trade Marks, Copyright, The rational for their protection. The international conventions: the Berne convention, Universal copyright convention, the Paris convention, WIPO, TRIPS, UNESCO

UNIT –II: INTERNATIONAL CONVENTIONS AND TREATIES (10 Hours)

International instruments relating to patents; patent cooperation treaty, Budapest treaty, Eurasian Patent convention Trademarks – Madrid convention, Lisbon agreement. Copyrights and neighboring rights – Berne convention, universal copyright convention, Rome convention, Universal copyright convention WIPO TRIPs

UNIT –III: THE LEGAL REGIME OF IPR'S IN INDIA (10 Hours)

The Patent (Amendment) Act 2005, The Trade Marks Act 1999, The Copyright Act 1957, Comparative Study of Legal Frame Work in U.S & Japan.

UNIT –IV: IPRs EMERGING AREAS AND CYBER LAWS (10 Hours)

Geographical Indications, Protection of plant varieties – Indian Perspective, Public Health Issues, Traditional Knowledge, Biological diversity – Convention on Bio – diversity, Case study, Patent Protection for pharmaceutical and Agricultural Chemical Products. Monsanto VsSchmeiser, Basumathi, Turmeric, Overview of cyber Law- Regulation of cyber space Cybercrimes. IT Act 2000. It (Amendment) Act 2008

TEXT BOOKS:

1. Intellectual Property Law, B.L Wadhera.
2. Intellectual Property Rights and the Law, G.B Reddy.

REFERENCE BOOKS

1. Intellectual property Right -A premiere, Prof.R.AnitaRao&Prof.V.BhanojiRao, EBC Publications

WEB REFERENCES

1. http://nptel.ac.in/courses/109103024/40
2. http://nptel.ac.in/courses/109105112/

FORMAL LANGUAGES AND AUTOMATA THEORY								
Course Code	**CS 6E10**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Fundamental of computer science and mathematics							
Objectives:	• To introduce concepts in formal language and automata theory. • To identify different formal language classes and their relationships. • To design grammars and recognizers for different formal languages • To design Turing Machine to accept Universal Language							

CO1	Remember and understand the basic concepts/Principles of formal languages and automata theory.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION (10 Hours)

Strings, Alphabet, Language, Operations, Finite state machine, definitions, finite automaton model, acceptance of strings, and languages, deterministic finite automaton and non-deterministic finite automaton, transition diagrams and Language recognizers. NFA with epsilon transition, acceptance of languages. Equivalence of NFA and DFA, NFA to DFA conversion, minimization of FSM. FA with output: Moore and Mealy machine, Equivalence of Moore and Mealy Machine, Applications and Limitation of FA.

UNIT –II: REGULAR EXPRESSION (08 Hours)

Regular sets, regular expressions, identity rules, Constructing finite Automata for a given regular expressions, Conversion of Finite Automata to Regular expressions. Pumping lemma of regular sets, Problems based on pumping lemma, closure properties of regular sets, Decision properties of regular languages.

UNIT –III: CONTEXT FREE GRAMMAR (12 Hours)

Definition, Examples, Derivation, Derivation trees, Ambiguity in Grammar, Inherent ambiguity, Ambiguous to Unambiguous CFG, Useless symbols, Simplification of CFGs, Normal forms for CFGs: CNF and GNF, Closure proper ties of CFLs, Decision Properties of CFLs: Emptiness, Finiteness and Membership, Pumping lemma for CFLs

Push Down Automata (PDA): Description and definition, Instantaneous Description, Language of PDA, Acceptance by Final state, Acceptance by empty stack, Deterministic PDA, Equivalence of PDA and CFG, CFG to PDA and PDA to CFG, PDA with two stacks.

UNIT –IV: TURING MACHINES (10 Hours)

Basic model, definition and representation, Instantaneous Description, Language acceptance by TM, Variants of Turing Machine, TM as Computer of Integer functions, Universal TM, Recursive and recursively enumerable languages, Halting problem, Introduction to Undecidability, Undecidable problems about TMs. Post correspondence problem (PCP), Modified PCP, Introduction to recursive

function theory

TEXT BOOKS:

1. John E. Hopcroft, Rajeev Motwani and Jeffery D. Ullman, Automata Theory, Languages, and Computation (3rd. Edition), Pearson Education, 2008.
2. Peter Linz ,An Introduction to Formal Languages and Automata, Paperback – 2011

REFERENCE BOOKS:

1. K. L. P. Mishra and N. Chandrashekaran, Theory of Computer Science: Automata, Languages and Computation, Indian 3rd Edition 2006.
2. H.R.Lewis and C.H.Papadimitriou, Elements of The theory of Computation, Second Edition, Pearson Education/PHI, 2003
3. Michael Sipser, Introduction to the Theory of Computation, Books/Cole Thomson Learning, 2001.

Other References: (Web)

- http://nptel.ac.in/courses/106104148/
- https://onlinecourses.nptel.ac.in/noc17_cs34/preview
- http://nptel.ac.in/courses/106104028/

IMAGE PROCESSING								
Course Code	**CS 6E11**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	A fundamental study on matrix convention, probability theory and statistical principles are needed to be learned.							
Objectives:	• To understand the digital image and different processing techniques for the better analysis of an image. • To study of digital images, bits and bytes, raster scan format, quantization, understanding of scaling, translation, rotation, sums and differences. • To study of contrast and grey levels, histograms, Gaussian and other non-linear stretches, understanding of topography. • Shaded relief displays, contours, parallax and stereo, perspective viewing. • Study on image morphing, false color images, principal components analysis.							

CO1	Remember and understand the basic concepts/Principles of image processing.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: DIGITAL IMAGE FUNDAMENTALS AND TRANSFORMS (10 Hours)

Elements of visual perception: Light, Brightness adaption and discrimination, Pixels, coordinate conventions, Imaging Geometry, Image sampling and quantization Basic relationship between pixels: Basic geometric transformations-Introduction to Fourier Transform and DFT : Properties of 2DFourier Transform , FFT, Separable Image Transforms ,Walsh – Hadamard –Discrete Cosine Transform, Haar, Slant – Karhunen – Loeve transforms. Perspective Projection, Spatial Domain Filtering, sampling and quantization.

UNIT –II: IMAGE ENHANCEMENT TECHNIQUES (10 Hours)

Spatial Domain methods: Basic grey level transformation, Histogram equalization, Image subtraction, Image averaging, Spatial filtering: Smoothing, sharpening filters, Laplacian filters, Frequency domain filters: Smoothing, Sharpening filters, Homomorphic filtering.

UNIT –III: IMAGE RESTORATIONAND IMAGE COMPRESSION (10 Hours)

Model of Image Degradation/restoration process: Noise models, Inverse filtering, Least mean square filtering, Constrained least mean square filtering, Blind image restoration, Pseudo inverse, Singular value decomposition.

Lossless compression: Variable length coding: LZW coding, Bit plane coding, predictive coding, DPCM. Lossy Compression: Transform coding – Wavelet coding – Basics of Image compression standards: JPEG, MPEG, Basics of Vector quantization

UNIT –IV: IMAGE SEGMENTATION AND REPRESENTATION , ADVANCES IN DIP (10 Hours)

Edge detection: Thresholding, Region Based segmentation, Boundaryrepresentation: chair codes, Polygonal approximation, Boundary segments:boundary descriptors: Simple descriptors, Fourier descriptors, Regional descriptors, Simple descriptors, Texture

TEXT BOOKS:

1. Digital Image Processing, 3rd Edition, by Rafael C Gonzalez and Richard E Woods. Publisher: Pearson Education.

REFERENCE BOOKS:

1. Fundamentals of Digital Image Processing, By Anil K Jain
2. Digital Image Processing, By William K Pratt, John Willey (2001)
3. Image Processing Analysis and Machine Vision, By Millman Sonka, Vaclav hlavac, Roger Boyle, Broos/colic, Thompson Learniy (1999).
4. Digital Image Processing and Applications, By, B. Chanda, D. DuttaMagundar, Prentice Hall of India, 2000
5. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing using MATLAB, McGraw Hill, 2011.

WEB REFERENCES

1. http://nptel.ac.in/courses/117105079/

HIGH PERFORMANCE COMPUTING								
Course Code	**CS 6E12**	**L-P-T-Cr.:**	**3**	**0**	**0**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Computer Architecture, Advanced Computer Architeture, OS							
Objective:	The course highlights different features of High-Performance Computing, and how they can be implemented through the hardware (architectural features) and system software (operating systems, run-time systems).							

CO1	Remember and understand the basic concepts/Principles of high performance computing.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT-I: Basics of High Performance Computing (10 hours)

RISC processors, Characteristics of RISC processors, RISC vs. CISC, Classification of instruction set architectures, Review of performance measurements, Basic parallel processing techniques: instruction level, thread level and process level.Need of high speed computing – increase the speed of computers – history of parallel computers and recent parallel computers; solving problems in parallel – temporal parallelism – data parallelism – comparison of temporal and data parallel processing – data parallel processing with specialized processors – inter-task dependency. The need for parallel computers - models of computation - analyzing algorithms – expressing algorithms.

UNIT-II: Pipelining Concepts (10 hours)

Principles of pipelining and vector processing - Linear pipelining - Classification of pipeline processors - General pipelines - Instruction and Arithmetic pipelines –Design of Pipelined instruction unit-Principles of Designing Pipeline Processors- Instruction prefetch and branch handling- Data Buffering and Busing Structure-Internal forwarding and register tagging, Hazard detection and Resolution, Dynamic pipelines and Reconfigurability

UNIT-III: Introduction To Dataflow And Multi-Processor Systems (10 hours)

Dataflow computers - Data driven computing and Languages, Data flow computers architectures - Static data flow computer, Dynamic data flow computer, Data flow design alternatives.Multi-Processors: Centralized vs. distributed shared memory, Interconnection topologies, Multiprocessor architecture, Symmetric multiprocessors, Cache coherence problem, memory consistency, Multicore architecture

UNIT-IV: Concepts Of Memories And Process Management (14 hours)

Virtual memory: Use of memory by programs, Address translation, Paging, Cache memory: Organization, impact on programming. Operating systems: Processes and system calls, Process management, Program profiling, File systems: Disk management, Name management, Protection, Parallel architecture: Inter-process communication, Synchronization, Mutual exclusion, Basics of parallel architecture, Parallel programming with message passing using MPI.

TEXTBOOK:

1. Hennessey and Patterson, “Computer Architecture: A Quantitative Approach”, Morgan

Kaufman.2004.

REFERENCE BOOK

1. K. Hwang, F. A. Briggs, “Computer architecture and parallel processing”, McGraw-Hill.

INTERNET OF THINGS								
Course Code	**CS 6E13**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Basic of Computer networks							
Objectives:	• To Understand the Architectural Overview of IoT • Understand the vision of IoT from a global context. • Understand the application of IoT. • Determine the Market perspective of IoT.							

CO1	Remember and understand the basic concepts/Principles of internet of things.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION (10 Hours)

The Internet of Things Today, Time for Convergence, Towards the IoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Applications, Future Internet Technologies, Infrastructure, Networks and Communication, Processes, Data Management, Security, Privacy & Trust, Device Level Energy Issues, IoT Related Standardization, Recommendations on Research Topics.

UNIT –II: IOT ARCHITECTURE (10 Hours)

IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management..

UNIT –III: IOT LAYERS PROTOCOLS (10 Hours)

PHY/MAC Layer (3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART,Z-Wave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT

UNIT –IV: INTERNET OF THINGS PRIVACY, SECURITY AND GOVERNANCE (10Hours)

Introduction, Overview of Governance, Privacy and Security Issues, Contribution from FP7 Projects, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities, Security.

TEXT BOOKS:

1. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, StamatisKarnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press, 2014
2. VijayMadisetti and ArshdeepBahga, “Internet of Things (A Hands-on-Approach)”, 1st Edition,VPT, 2014

REFERENCE BOOKS:

1. Peter Waher, “Learning Internet of Things”, PACKT publishing, BIRMINGHAM – MUMBAI
2. Bernd Scholz-Reiter, Florian Michahelles, “Architecting the Internet of Things”, ISBN 978-3-

642-19156-5 e-ISBN 978-3-642-19157-2, Springer

WEB REFERENCES

- https://onlinecourses.nptel.ac.in/noc17_cs22/preview

STORAGE AREA NETWORK								
Course Code	**CS 6E14**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Knowledge of Computer Networks and DBMS							
Objective:	To learn H/W and S/W architecture, various features of Storage area Network (SAN) as well as its applications.							

CO1	Remember and understand the basic concepts/Principles of storage area network.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION AND INTELLIGENT DISK SUBSYSTEMS (10 Hours)

Introduction: Server Centric IT Architecture and its Limitations; Storage – Centric IT Architecture and its advantages. Case study: Replacing a server with Storage Networks .The Data Storage and Data Access problem; The Battle for size and Access

Intelligent Disk Subsystems: Architecture of Intelligent Disk Subsystems; Hard disks and Internal I/O Channels; JBOD, Storage virtualization using RAID and different RAID levels; Caching: Acceleration of Hard Disk Access; Intelligent disk subsystems, Availability of disk subsystems

UNIT –II: I/O TECHNIQUES, NETWORK ATTACHED STORAGE AND FILE SYSTEM AND NAS (10 Hours)

I/O Techniques: The Physical I/O path from the CPU to the Storage System; SCSI; Fiber Channel Protocol Stack; Fibre Channel SAN; IP Storage

Network Attached Storage: The NAS Architecture, The NAS hardware Architecture, The NAS Software Architecture, Network connectivity, NAS as a storage system.

File System and NAS: File System and NAS: Local File Systems; Network file Systems and file servers; Shared Disk file systems; Comparison of fiber Channel and NAS.

UNIT –III: STORAGE VIRTUALIZATION AND SAN ARCHITECTURE & HARDWARE DEVICES (10 Hours)

Storage Virtualization: Definition of Storage virtualization; Implementation Considerations; Storage virtualization on Block or file level; Storage virtualization on various levels of the storage Network; Symmetric and Asymmetric, Storage virtualization in the Network.

SAN Architecture and Hardware devices: Overview, Creating a Network for storage; SAN Hardware devices; The fiber channel switch; Host Bus Adaptors; Putting the storage in SAN; Fabric operation from a Hardware perspective.

UNIT –IV: SOFTWARE COMPONENTS OF SAN AND MANAGEMENT (10 Hours)

Software Components of SAN: The switch's Operating system; Device Drivers; Supporting the switch's components; Configuration options for SANs.

Management: Planning Business Continuity; Managing availability; Managing Serviceability; Capacity planning; Security considerations

TEXT BOOKS:

1. Ulf Troppens, Rainer Erkens and Wolfgang Muller: Storage Networks, Wiley India, 2007
2. Robert Spalding: Storage Networks The Complete Reference, Tata McGraw-Hill, 2003.

REFERENCE BOOKS:

1. Richard Barker and Paul Massiglia: Storage Area Network Essentials A Complete Guide to understanding and Implementing SANs, John Wiley India, 2002

WEB REFERENCES

1. http://nptel.ac.in/courses/106108058/

GAME THEORY								
Course Code	**CS 6E15**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Foundation of Mathematics, Artificial Intelligence							
Objectives:	• To introduce a basic level combinatorial and cooperative games. • To analyze conflicting situations using game theory.							

CO1	Remember and understand the basic concepts/Principles of game theory.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: (10 Hours)

Introduction: Game Theory, Games and Solutions Game Theory and the Theory of Competitive Equilibrium, Rational Behavior, The Steady State and Deductive Interpretations, Bounded Rationality Terminology and Notation

Nash Equilibrium- Strategic Games, Nash Equilibrium Examples Existence of a Nash Equilibrium, Strictly Competitive Games, Bayesian Games: Strategic Games with Imperfect Information

Mixed, Correlated, and Evolutionary Equilibrium -Mixed Strategy Nash Equilibrium Interpretations of Mixed Strategy Nash Equilibrium Correlated Equilibrium Evolutionary Equilibrium

UNIT –II: (10 Hours)

Rationalizability and Iterated Elimination of Dominated Actions-Rationalizability Iterated Elimination of Strictly Dominated Actions, Iterated Elimination of Weakly Dominated Actions.

Knowledge and Equilibrium -A Model of Knowledge Common Knowledge, Can People Agree to Disagree? , Knowledge and Solution Concepts, The Electronic Mail Game

UNIT –III: (10 Hours)

Extensive Games with Perfect Information -Extensive Games with Perfect Information Subgame Perfect Equilibrium Two Extensions of the Definition of a Game The Interpretation of a Strategy , Two Notable Finite Horizon Games , Iterated Elimination of Weakly Dominated Strategies Bargaining Games -Bargaining and Game Theory , A Bargaining Game of Alternating Offers Subgame Perfect Equilibrium Variations and Extensions

UNIT –IV: SOFTWARE COMPONENTS OF SAN AND MANAGEMENT (10 Hours)

Repeated Games - The Basic Idea Infinitely Repeated Games vs.\ Finitely Repeated Games Infinitely Repeated Games: Definitions Strategies as Machines Trigger Strategies: Nash Folk Theorems Punishing for a Limited Length of Time: A Perfect Folk Theorem for the Limit of Means Criterion Punishing the Punisher: A Perfect Folk Theorem for the Overtaking Criterion Rewarding Players Who Punish: A Perfect Folk Theorem for the Discounting Criterion The Structure of Subgame Perfect Equilibria Under the Discounting Criterion Finitely Repeated Game

TEXT BOOKS:

1. M. J. Osborne and A. Rubinstein, A course in Game Theory, MIT Press
2. Roger Myerson, Game Theory, Harvard University Press
3. D. Fudenberg and J. Tirole, Game Theory, MIT Press

REFERENCE BOOKS:

1. J. von Neumann and O. Morgenstern, Theory of Games and Economic Behavior, New York: John Wiley and Sons.
2. R.D. Luce and H. Raiffa, Games and Decisions, New York: John Wiley and Sons.,
3. G. Owen, Game Theory, (Second Edition), New York: Academic Press,

WEB REFERENCES

1. http://nptel.ac.in/courses/112106131/33
2. https://onlinecourses.nptel.ac.in/noc16_mg01/preview

SOFTWARE DEFINED NETWORK								
Course Code	**CS 6E16**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Data Communication Networks							
Objectives:	• Explain the key benefits of SDN by the separation of data and control planes. • Apply techniques that enable applications to control the underlying network using SDN							

CO1	Remember and understand the basic concepts/Principles of software defined network.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT-I SDN BACKGROUND AND MOTIVATION (10 Hours)

Evolving network requirements-The SDN Approach: Requirements, SDN Architecture, Characteristics of Software-Defined Networking, SDN and NFV-Related Standards: Standards-Developing Organizations, Industry Consortia, Open Development Initiatives.

UNIT-II SDN DATA PLANE AND OPENFLOW (12 Hours)

SDN data plane: Data plane Functions, Data plane protocols, Openflow logical network Device: Flow table**.** Structure, Flow Table Pipeline, The Use of Multiple Tables, Group Table- OpenFlow Protocol**.**

UNIT-III SDN CONTROL PLANE AND APPLICATION PLANE (14 Hours)

SDN Control Plane Architecture: Control Plane Functions, Southbound Interface, Northbound Interface, Routing, ITU-T Model- Open Daylight-REST- Cooperation and Coordination Among Controllers.

SDN Application Plane Architecture: Northbound Interface, Network Applications, User Interface-Network Services. Abstraction Layer: Abstractions in SDN, Frenetic- Traffic Engineering Measurement and Monitoring**,** Security- Data Center Networking- Mobility and Wireless.

UNIT-IV NETWORK FUNCTIONS VIRTUALIZATION (10 Hours)

Background and Motivation for NFV- Virtual Machines- NFV Concepts: Simple Example of the Use of NFV, NFV Principles, High-Level NFV Framework, NFV Benefits and Requirements- NFV Reference Architecture: NFV Management and Orchestration.

TEXT BOOKS

1. William Stallings, "Foundations of Modern Networking", Pearson Ltd.,2016.

2. Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black,Morgan Kaufmann Publications, 2014

3. SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013

REFERENCE BOOKS

1. Feamster, Nick, Jennifer Rexford, and Ellen Zegura. "The road to SDN: an intellectual history of programmable networks." ACM SIGCOMM Computer Communication Review 44.2 (2014): 87-98.

2. Kreutz et al. "Software-defined networking: A comprehensive survey." Proceedings of the IEEE 103.1 (2015), 14-76

MACHINE LEARNING								
Course Code	**CS 6E17**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Basic of Algorithm, Linear Algebra, Vector Space, Probability and Statistics							
Objectives:	• To know about supervised and unsupervised Learning. • To study about feature extraction and structural pattern recognition. • To explore different classification models. • To learn about fuzzy pattern classifiers and perception.							

CO1	Remember and understand the basic concepts/Principles of machine learning.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: (10 Hours)

Introduction: Learning problems, perspectives and issues, concept learning, version spaces and candidate eliminations, inductive bias, decision tree learning, representation, algorithm, heuristic space search.

Neural Networks And Genetic Algorithms: Neural network representation, problems, perceptrons, multilayer networks and back propagation algorithms, advanced topics,

UNIT –II: (10 Hours)

Genetic algorithms, hypothesis space search, genetic programming, models of evaluation and learning.

Bayesian and Computational Learning: Bayes theorem, concept learning, maximum likelihood, minimum description length principle, Bayes optimal classifier, Gibbs Algorithm, Naïve Bayes Classifier, Bayesian belief network.

UNIT –III: (12 Hours)

EM algorithm, probability learning, sample complexity, finite and infinite hypothesis spaces, mistake bound model.

Instance Based Learning: K-Nearest neighbour learning, locally weighted regression, radial basis functions, case based learning.

UNIT –IV: (08 Hours)

Hidden Markov Models: Introduction, discrete Markov processes, hidden Markov models, three basic problems of HMMs evaluation problem, finding the state sequence, learning model parameters, continuous observations, the HMM with input, model selection in HMM.

TEXT BOOKS:

1. Tom M. Mitchell, Machine Learning, McGraw Hill , 2013.
2. EthemAlpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004

REFERENCE BOOKS:

1. T. Hastie, R. Tibshirani, J. H. Friedman, The Elements of Statistical Learning, 1/e, Springer, 2001.
2. M NarasimhaMurty, Introduction to Pattern Recognition and Machine Learning, World Scientific Publishing Company, 2015

WEB REFERENCES

1. http://www.ph.tn.tudelft.nl/PRInfo/
2. http://kdd.ics.uci.edu/
3. http://morden.csee.usf.edu/nnc/index1.html
4. http://www.iapr.org/

BIO DATA ANALYTICS								
Course Code	**CS 6E18**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Basic Computer Network, Cloud Computing and Database system.							
Objectives:	• Understand the Big Data Platform and its Use cases. • Provide an overview of Apache Hadoop. • Provide HDFS Concepts and Interfacing with HDFS. • Understand Map Reduce Jobs. • Provide hands on Hodoop Eco System. • Apply analytics on Structured, Unstructured Data.							

CO1	Remember and understand the basic concepts/Principles of Bio data analytics.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: **08 hours**

Introduction: Big data and its importance, a flood of mythic "start up" proportions, big data is more than merely big why now? A convergence of key trends, a wider variety of data, the expanding universe of unstructured data, industry examples of big data: Digital marketing and the online world, the right approach, cross channel lifecycle marketing.

UNIT – II: **12 hours**

Big Data Technology: The elephant in the room: Hadoop's parallel world, old vs. new approaches. Data discovery: Work the way people's minds work, open source technology for big data analytics, the cloud and big data, predictive analytics moves into the limelight, a brief history of hadoop, apache hadoop and the hadoop ecosystem.

MapReduce: Analyzing the data with hadoop, map and reduce, java mapreduce, scaling out, data flow, combiner functions, running a distributed mapreduce job, hadoop streaming, the hadoop distributed file system, thedesign of HDFS, HDFS concepts, blocks, name nodes and data nodes, HDFS federation, HDFS high, availability, the command, line interface, basic file system operations, hadoop file systems.

UNIT – III: **12 hours**

Information Management: The big data foundation, big data computing platforms, big data computation, more on big data storage, big data computational limitations, big data emerging technologies. Business analytics: The last mile in data analysis, geospatial intelligence will make your life better, consumption of analytics, from creation to consumption. Visualizing: How to make it consumable? Organizations are using data visualization as a way to take immediate action.

UNIT – IV: **10 hours**

Data Privacy and Ethics :The privacy landscape, the great data grab isn't new, preferences, personalization, and relationships, rights and responsibility, playing in a global sandbox , conscientious and conscious responsibility, privacy may be the wrong focus can data be anonymized? Balancing for counter intelligence.

TEXT BOOKS

1. MichaelMinelli, Michele Chambers, Big Data,Big Analytics, Wiley Publications, 2013
2. Tom White, Hadoop: The Definitive Guide, 3/e, O'Reilly Publications, 2012.

REFERENCE BOOKS:

1. Bill Franks Taming, The Big Data Tidal Wave, 1/e, Wiley, 2012.
2. Frank J. Ohlhorst, Big Data Analytics, 1/e, Wiley, 2012

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- https://wr.informatik.uni-hamburg.de/_media/teaching/wintersemester_2015_2016/bd-1516-einfuehrung.pdf

CLOUD COMPUTING								
Course Code	**CS 6E19**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Basic of Computer networks							
Objectives:	• To develop the understanding of fundamentals and technological aspects of Cloud Computing. Management of cloud services. • The objective is to learn emerging techniques in cloud computing and its applications, fault tolerance and security in cloud, learn different Resource Allocation, Leases, Task scheduling algorithms. • Introduction to Energy Efficient Task Consolidation, High-Throughput Computing, and knowledge about CloudSim, Cloudlet, Virtual Machine and its Provisioning. • Virtualization along with various terminologies and the keywords used in Cloud Computing and virtualization. Storage network design and optimization							

CO1	Remember and understand the basic concepts/Principles of cloud computing.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: **10 hours**

Introduction; Distributed Data Processing, Distributed Database System, Promises of DDBSs, Problem areas. Cloud Computing definition, private, public and hybrid cloud. Cloud types; IaaS, PaaS, SaaS. Benefits and challenges of cloud computing, public vs private clouds, role of virtualization in enabling the cloud; Business Agility: Benefits and Challenges to Cloud architecture. Application availability, performance, security and disaster recovery.

UNIT – II: **8 hours**

Reliability, availability and security of services deployed from the cloud. Performance and scalability of services, tools and technologies used to manage cloud services deployment; Cloud Economics: Cloud Computing infrastructures available for implementing cloud based services.

UNIT – III: **12 hours**

Cloud infrastructures; public, private, hybrid. Service provider interfaces; Saas, Paas, Iaas. VDC environments; concept, planning and design, business continuity and disaster recovery principles. Managing VDC and cloud environments and infrastructures. Storage strategy and governance; security and regulations. Designing secure solutions; the considerations and implementations involved. Securing storage in virtualized and cloud environments.

UNIT – IV: **10 hours**

Architecture of storage, analysis and planning. Storage network design considerations; NAS and FC SANs, hybrid storage networking technologies (iSCSI, FCIP, FCoE), design for storage virtualization in cloud computing, host system design considerations. Global storage management locations, scalability, operational efficiency. Global storage distribution; terabytes to petabytes and greater.

TEXT BOOKS

1. Greg Schulz, "Cloud and Virtual Data Storage Networking", Auerbach Publications [ISBN: 978-1439851739], 2011.
2. GautamShroff, "Enterprise Cloud Computing Technology Architecture Applications", Cambridge University Press; 1 edition, [ISBN: 978-0521137355], 2010.

REFERENCE BOOKS:

1. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A PracticalApproach" McGraw-Hill Osborne Media; 1 edition [ISBN: 0071626948], 2009.
2. Dimitris N. Chorafas, "Cloud Computing Strategies" CRC Press; 1 edition[ISBN: 1439834539], 2010.
3. EMC, "Information Storage and Management" Wiley; 2 edition [ISBN: 9780470294215], 2012.

SOFT COMPUTING								
Course Code	**CS 6E20**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Probability and Statistics, Vectors, C++/Java/ Matlab programming							
Objectives:	• To study the techniques of soft computing, especially evolutionary computation, fuzzy logic, GA and neural networks. • Applying hybrid of multiple techniques and choosing the appropriate technique for the problems that one want to solve.							

CO1	Remember and understand the basic concepts/Principles of soft computing.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: **16 hours**

Introduction to Soft Computing, Historical Development, Definitions, advantages and disadvantages, solution of complex real-life problems.

Artificial Neural Network: Introduction, basic models, Hebb's learning, Adaline, Perceptron, Multilayer feed forward network, Back propagation, Different issues regarding convergence of Multilayer Perceptron, Competitive learning, Self-Organizing Feature Maps, Adaptive Resonance Theory, Associative Memories, Deep Neural Network, Applications.

UNIT – II: **10 hours**

Fuzzy Logic: Introduction to Fuzzy Logic, Classical and Fuzzy Sets: Overview of ClassicalSets, Membership Function, Fuzzy rule generation. Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations. Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals &Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations.

UNIT – III: **10 hours**

Evolutionary and Stochastic techniques: Genetic Algorithm (GA), different operators of GA, analysis of selection operations, Hypothesis of building blocks, Schema theorem and convergence of Genetic Algorithm, Simulated annealing and Stochastic models, Boltzmann Machine, Applications.

UNIT – IV: **12 hours**

Hybrid Systems: Neural-Network-Based Fuzzy Systems, Fuzzy Logic-Based Neural Networks, Genetic Algorithm for Neural Network Design and Learning, Fuzzy Logic and Genetic Algorithm for Optimization, Applications.

TEXT BOOKS

1. Jang, “Neuro-Fuzzy and Soft computing”, Sun, Mizutani, Pearson
2. Haykin, “Neural networks: a comprehensive foundation”,
3. Goldberg, “Genetic Algorithms”,
4. G.J. Klir& B. Yuan, “FuzzySets& Fuzzy Logic”, PHI.

REFERENCE BOOKS:

1. Anderson J.A., “An Introduction to Neural Networks”, PHI, 1999
2. Hertz J. Krogh, R.G. Palmer, “Introduction to the Theory of Neural Computation”, Addison-Wesley, California,
3. Melanie Mitchell, “An Introduction to Genetic Algorithm”, PHI, 1998.
4. “Neural Networks-A Comprehensive Foundations”, Prentice-Hall International, New Jersey, 1999.
5. Freeman J.A. & D.M. Skapura, “Neural Networks: Algorithms, Applications and Programming Techniques”, Addison Wesley, Reading, Mass, (1992).

REAL TIME SYSTEM								
Course Code	**CS 6E21**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Data Structure and Algorithm, Linear Algebra, Basics of Web programming							
Objectives:	• Basics of Real time systems • Real time memory and design considerations • Integration of Hardware and software in real time applications							

CO1	Remember and understand the basic concepts/Principles of real time system.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION (8 Hours)

Basic real time concepts - Introduction, Real-time Versus Conventional Software, Computer Hardware for Monitoring and Control, Software Engineering Issues.

UNIT –II: DESIGN TECHNIQUES AND MEMORY MANAGEMENT (10 Hours)

Real time specification and design techniques – structure of an RTOS - real time kernels – inter task communication and synchronization. Real time memory management. System performance analysis and optimization.

UNIT –III: QUEUING MODELS AND FAULT TOLERANT ARCHITECTURE (9 Hours)

Queuing models – Reliability, testing and fault tolerance, HW/SW faults, diagnosis, functional testing. Fault tolerant architectures: TMR systems - multiprocessing systems.

UNIT –IV: REAL-TIME DATABASES AND COMMUNICATION, APPLICATIONS (13 Hours)

Introduction – Main Memory Databases – Transaction Priorities – Concurrency Control Issues – Disk Scheduling Algorithms – Databases for Hard Real-Time Systems – Fault-Tolerant Routing

Hardware/Software integration, real time applications- case studies

TEXT BOOKS:

1. LaplantePhilip.A, “Real-time systems design and analysis: An engineer’s handbook”, 2nd Edition, PHI.,1994.
2. C.M.Krishna, Kang G.Shin, “Real-time systems” – McGraw Hill, 1997.

REFERENCE BOOKS:

1 Alan C. Shaw, “Real – Time Systems and software”, John Wiley & Sons Inc,2001
2 Buhr R J and Bailey D L, “An Introduction to Real-Time Systems”, Prentice-Hall 1999.
3 Burns, A and Wellings, A, “Real Time Systems and Programming Languages: Ada 95, Real-Time Java and Real-Time C/POSIX”, Addison-Wesley. ISBN.,2001
4 Levi S.T. and Agarwal A.K., “Real time System Design”, McGraw Hill International Edition, 1990.
5 Rajibmall “Realtime systems, Theory & Practice “ , Pearson Education 2007.

WEB REFERENCES

1 www.eventhelix.com/realtimemantra/basics
2 www.unix.ecs.umass.edu/~krishna
3 http://infoweb.vub.ac.be/infoef/ulbarch/
4 www.augustana.ab.ca/~mohrj/courses/2005.winter/cs380/slides.7e

SOFTWARE ENGINEERING								
Course Code	**CS 6E22**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Knowledge on programming and data structure							
Objectives:	• To understand common cycle process life processes. • To understand the basic concepts in Requirement engineering, software design, coding, testing and maintenance • To learn about the role of project management including scheduling, planning, risk management etc. • To have a basic knowledge about software quality, how to ensure good quality software.							

CO1	Remember and understand the basic concepts/Principles of software engineering.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: **(12 Hours)**

Introduction to software and software engineering, various software process modules, capability, maturity, module and KPAs. Project planning, project introduction, team organization, scheduling and management, constructive cost model. Software measures, indicators and metrics, software risk analysis and management.

UNIT –II: **(12 Hours)**

Software requirement analysis and specifications, applicability to small, medium, and large-scale systems. Software design, technical design, objectives of design, design metrics, modularity, module coupling and cohesion, relation between cohesion and coupling; Design strategies: Bottom up design, top down design, functional oriented design, object oriented design; IEEE recommended practice for software design description

UNIT –III: **(12 Hours)**

Software testing, testability, testing process, structural testing, unit testing and integrated testing, debugging, testing tools, software maintenance, maintenance process, maintenance cost, reverse engineering and reengineering.

UNIT –IV: **(12 Hours)**

Configuration management, Software Quality: Evolution of software quality, assessing and controlling software quality. Software reliability: Hardware vs Software reliability, Reliability metrics. CASE tools and workbenches.

TEXT BOOKS:

1. Software Engineering, A practitioner's Approach - Roger S. Pressman, 6th edition, McGraw Hill International Edition.

REFERENCE BOOKS

1. Software Engineering, an Engineering approach- James F. Peters, WitoldPedrycz, John Wiely.
2. Software Engineering principles and practice- Waman S Jawadekar, The McGraw-Hill Companies.
3. Fundamentals of object-oriented design using UML Meiler page-Jones: Pearson Education

WEB REFERENCES

1. http://nptel.ac.in/courses/106101061/
2. http://www.nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Soft%20Engg/New_index1.html

WIRELESS SENSOR NETWORK & APPLICATIONS								
Course Code	**CS 6E23**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Basic of Computer networks							
Objectives:	The purpose of this course is to introduce students to • Obtain a broad understanding about the network architecture of wireless sensor network. • Understand all basic characteristics of wireless sensor networks and sensor nodes. • The principles of data transmission, clustering algorithm and routing protocols. • Design and development of new network architecture and MAC protocols. • Understand various application of Wireless Sensor Network							

CO1	Remember and understand the basic concepts/Principles of wireless sensor network & applications.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT –I: INTRODUCTION (10 Hours)

Networked wireless sensor devices, Key design challenges. **Network deployment:** Structured versus randomized deployment, Network topology, Connectivity, **Application:** Applications: Habitat Monitoring, Smart Transportation, detecting unauthorized activity using a sensor network**,** SUltra wide band radio communication, and Wireless fidelity systems. Future directions, Home automation, smart metering Applications.

UNIT –II: LOCALIZATION AND WIRELESS CHARACTERISTICS (10 Hours)

Localization: Issues & approaches, Coarse-grained & Fine-grained node localization, Network-wide localization. **Wireless characteristics:** Basics, Wireless link quality, Radio energy considerations, SINR capture model for interference.

UNIT –III: MEDIUM-ACCESS AND SLEEP SCHEDULING (10 Hours)

Issues in designing MAC protocol for WSNs, Classification of MAC Protocols, Energy efficiency in MAC protocols, Asynchronous sleep techniques, Sleep-scheduled techniques.

Classification of Energy Management Schemes, Transmission Power Management Schemes, System Power Management Schemes, Energy harvesting for self-sustainable WSNs.

UNIT –IV: ROUTING AND INTEGRATION OF SENSOR & CLOUD SYSTEM (10 Hours)

Routing: Metric-based approaches, Routing with diversity, Multi-path routing, Lifetime-maximizing energy-aware routing techniques, Geographic routing.

Introduction to cloud system, Sensor Cloud Systems, Challenges in Sensor Cloud Systems: Energy Efficiency issues, Storage issues, Design Issues. Classification of energy efficient sensor cloud techniques. Data prediction based energy efficient sensor cloud system.

TEXT BOOKS:

1. Wireless Sensor Networks: Technology, Protocols, and Applications: KazemSohraby, Daniel Minoli, TaiebZnati , Wiley Inter Science.
2. Networking Wireless Sensors: BhaskarKrismachari, Cambridge University Press

REFERENCE BOOKS:

1. Wireless Sensor Networks: Architectures and Protocols: Edgar H. Callaway, Jr. Auerbach Publications, CRC Press.
2. Wireless Sensor Networks: Edited by C.S Raghavendra, Krishna M, Sivalingam, TaiebZnati , Springer.
3. Distributed Sensor Networks: A Multiagent Perspective, Victor Lesser, Charles L. Ortiz, and MilindTambe, Kluwer Publications.
4. Wireless Sensor Networks: An Information Processing Approach- by Feng Zhao, Leonidas Guibas, Morgan Kaufmann Series in Networking 2004.

Other References: (Web)

- https://onlinecourses.nptel.ac.in/noc17_cs07/preview
- http://nptel.ac.in/courses/106105160/21

SEMANTIC WEB AND SOCIAL NETWORKING								
Course Code	**CS 6E24**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Web technology, Machine intelligence							
Objectives:	• To learn Web Intelligence • To learn Knowledge Representation for the Semantic Web • To learn Ontology Engineering • To learn Semantic Web Applications, Services and Technology • To learn Social Network Analysis and semantic web							

CO1	Remember and understand the basic concepts/Principles of semantic web and social networking.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: **08 hours**

Thinking and Intelligent Web Applications, The Information Age, The World Wide Web, Limitations of Today's Web, The Next Generation Web. Machine Intelligence, Artificial Intelligence, Ontology, Inference engines, Software Agents, Berners-Lee www, Semantic Road Map, Logic on the semantic Web

UNIT – II: **14 hours**

Ontologies and their role in the semantic web, Ontologies Languages for the Semantic Web —Resource Description Framework(RDF) / RDF Schema, Ontology Web Language(OWL), UML,XML/XML Schema. Ontology Engineering, Constructing Ontology, Ontology Development Tools, Ontology Methods, Ontology Sharing and Merging, Ontology Libraries and Ontology Mapping.
Logic, Rule and Inference Engines. Semantic Web applications and services, Semantic Search, e-learning, Semantic Bloinformatics, Knowledge Base.

UNIT – III: **10 hours**

XML Based Web Services, Creating an OWL-S Ontology for Web Services, Semantic Search Technology, Web Search Agents and Semantic Methods, What is social Networks analysis, development of the social networks analysis, Electronic Sources for Network Analysis — Electronic Discussion networks.

UNIT – IV: **08 hours**

Blogs and Online Communities, Web Based Networks. Building Semantic Web Applications with social

network features.

TEXT BOOKS

1. Thinking on the Web – Berners Lee, Godel and Turing, Wiley interscience, 2008.
2. Social Networks and the Semantic Web, Peter Mika, Springer, 2007.

REFERENCE BOOKS:

1. Semantic Web Technologies, Trends and Research in Ontology Based Systems, J. Davies, Audi Studer, Paul Warren, John Wiley & Sons.
2. Semantic Web and Semantic Web Services -Liyang Lu Chapman and Hall/CRC Publishers, (Taylor & Francis Group)
3. Information Sharing on the semantic Web – HeinerStuckenschmidt; Frank Van Harmelen, Springer Publications.
4. Programming the Semantic Web, T. Segaran, C. Evans, J. Taylor, O'ReiIly, SPD.

ADAVANCED OPERATING SYSTEMS								
Course Code	**CS 6E25**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Operating systems, Basics of Computer Architecture, Computer Networks							
Objective:	The main objective of studying this course is to understand concept distributed systems; clock synchronization issues, mutual exclusion, deadlock, resource management, system failure and fault tolerance, system protection model in distributed system.							

CO1	Remember and understand the basic concepts/Principles of adavanced operating systems.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: INTRODUCTION **08 hours**

INTRODUCTION :Overview - Functions of an Operating System – Design Approaches – Types of Advanced Operating System - Synchronization Mechanisms – Concept of a Process, Concurrent Processes– TheCritical Section Problem, Other Synchronization Problems – Language Mechanisms for Synchronization –Axiomatic Verification of Parallel Programs - Process Deadlocks - Preliminaries – Models of Deadlocks, Resources, System State – Necessary and Sufficient conditions for a Deadlock – Systems with Single-Unit Requests, consumable Resources, Reusable Resources.

UNIT – II: DISTRIBUTED OPERATING SYSTEMS **12 hours**

DISTRIBUTED OPERATING SYSTEMS: Introduction – Issues – Communication Primitives – Inherent Limitations - Lamport's Logical Clock; Vector Clock; Causal Ordering; Global State; Cuts; Termination Detection.

Distributed Mutual Exclusion – Non-Token Based Algorithms – Lamport's Algorithm - Token-Based Algorithms – Suzuki-Kasami's Broadcast Algorithm – Distributed Deadlock Detection – Issues – Centralized Deadlock-Detection Algorithms - Distributed Deadlock-Detection Algorithms. Agreement Protocols – Classification - Solutions – Applications.

UNIT – III: DISTRIBUTED RESOURCE MANAGEMENT **10 hours**

DISTRIBUTED RESOURCE MANAGEMENT: Distributed File systems – Architecture – Mechanisms – Design Issues – Distributed Shared Memory – Architecture – Algorithm – Protocols - Design Issues. Distributed Scheduling – Issues – Components – Algorithms.

FAILURE RECOVERY AND FAULT TOLERANCE: Basic Concepts-Classification of Failures – Basic Approaches to Recovery; Recovery in Concurrent System; Synchronous and Asynchronous Check pointing and Recovery; Check pointing in Distributed Database Systems; Fault Tolerance; Issues - Two-phase and Nonblocking Commit Protocols; Voting Protocols; Dynamic Voting Protocols;

UNIT – IV: FAILURE RECOVERY, FAULT TOLERENCE, AND RESOURCE SECURITY AND PROTECTION **10 hours**

MULTIPROCESSOR AND DATABASE OPERATING SYSTEMS: Structures – Design Issues – Threads – Process Synchronization – Processor Scheduling – Memory Management – Reliability / Fault Tolerance; Database Operating Systems – Introduction – Concurrency Control – Distributed Database Systems – Concurrency Control Algorithms.

TEXT BOOKS

1. Singhal, Mukesh& N.G. Shivaratri, Advanced Concepts in Operating Systems, TMH.

REFERENCE BOOKS:

1. P. K. Sinha, "Distributed Operating Systems" PHI, 1998.
2. A.S. Tanenbaum, Modern Operating Systems, PHI
3. G. Coluris, Distributed Systems-Concepts and Design.
4. Chow, Johnson, Distributed Operating Systems, Addison-Wesley

SOFTWARE PROJECT MANAGEMENT								
Course Code	**CS 6E26**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Basic of Software Engineering.							
Objectives:	• To know Project Evaluation and Planning. • To introduce the concept of Project Sequencing and Scheduling. • To know Quality Management and People Management.							

CO1	Remember and understand the basic concepts/Principles of software project management.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: Project Evaluation and Planning **10 hours**

Activities in Software Project Management, Overview Of Project Planning, Stepwise planning, contract management, Software processes and process models. Cost Benefit Analysis, Cash Flow Forecasting, Cost-Benefit Evaluation Techniques, Risk Evaluation. Project costing, COCOMO 2, Staffing pattern, Effect of schedule compression, Putnam's equation, Capers Jones estimating rules of thumb.

UNIT – II: Project Sequencing and Scheduling **12 hours**

Project Sequencing and Scheduling Activities, Scheduling resources, Critical path analysis, Network Planning, Risk Management, Nature and Types of Risks, Managing Risks, Hazard Identification, Hazard Analysis, Risk Planning and Control, PERT and Monte Carlo Simulation techniques.

UNIT – III: Monitoring And Control **08 hours**

Collecting Data, Visualizing Progress, Cost Monitoring, review techniques, project termination review, Earned Value analysis, Change Control, Software Configuration Management (SCM), Managing Contracts, Types of Contracts, Stages in Contract Placement, Typical Terms of a Contract, Contract Management and Acceptance.

UNIT – IV: Quality Management and People Management **10 hours**

Introduction, Understanding Behavior, Organizational Behaviour, Selecting The Right Person For The Job, Motivation, The Oldman – Hackman Job Characteristics Model, Working in Groups, Organization and team structures, Decision Making, Leadership, Organizational Structures, Stress, Health And Safety. ISO and CMMI models, Testing, and Software reliability, test automation, Overview of project management tools.

TEXT BOOKS

1. Bob Hughes, Mike Cotterell, "Software Project Management", Fifth Edition, Tata McGraw Hill, 2011.

REFERENCE BOOKS:

1. Royce, “Software Project Management”, Pearson Education, 1999.
2. Robert K. Wysocki, Effective Software Project Management, Wiley, 2009.

Other References: (Web)

- https://cs.uwaterloo.ca/~dberry/COURSES/software.engr/lectures.pdf/projman.pdf
- http://nptel.ac.in/courses/106101061/29
- http://nptel.ac.in/courses/106101061/29

PARALLEL ALGORITHMS								
Course Code	**CS 6E27**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Algorithm, Basics of Computer architecture							
Objectives:	• To learn parallel and distributed algorithms development techniques for shared memory and message passing models. • To study the main classes of parallel algorithms. • To study the complexity and correctness models for parallel algorithms.							

CO1	Remember and understand the basic concepts/Principles of Parallel algorithms.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I: **08 hours**

Basic Techniques, Parallel Computers for increase Computation speed, Parallel & Cluster Computing.

UNIT – II: **12 hours**

Message Passing Technique- Evaluating Parallel programs and debugging, Portioning and Divide and Conquer strategies examples

Pipelining- Techniques computing platform, pipeline programs examples

UNIT – III: **10 hours**

Synchronous Computations, load balancing, distributed termination examples, programming with shared memory, shared memory multiprocessor constructs for specifying parallelist sharing data parallel programming languages and constructs, open MP

UNIT – IV: **10 hours**

Distributed shared memory systems and programming achieving constant memory distributed shared memory programming primitives, algorithms – sorting and numerical algorithms.

TEXT BOOKS

1. Parallel Programming, Barry Wilkinson, Michael Allen, Pearson Education, 2nd Edition.

REFERENCE BOOKS:

1. Introduction to Parallel algorithms by Jaja from Pearson, 1992.

PROBABILITY AND STOCHASTIC PROCESS								
Course Code	**CS 6E28**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Fundamental of computer science and mathematics							
Objectives:	• To equip students with theoretical knowledge and practical skills • To analyze stochastic dynamical systems in economics, engineering and other fields. • To study various properties and characteristics of processes.							

CO1	Remember and understand the basic concepts/Principles of probability and stochastic process.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

UNIT – I:

Vector space, Inner product space, norm, Hilbert spaces. Projection theorem. SeparableHilbert spaces and orthonormal bases. Linear functionals. Riesz representation theorem.Probability spaces. Random variables and random vectors. Distributions and densities.

UNIT – II:

Statistical independence. Expectations, moments and characteristic functions.Infinite sequences of random variables. Convergence concepts. Laws of large numbers.Radon-Nikodym theorem. Conditional expectations given aσ-field and a random vector.Jensen's inequality.

UNIT – III:

Stochastic processes. Separability and measurability. Continuity concepts. GaussianProcesses and Wiener processes. Second order processes. Covariance functions and theirProperties. Linear operations and second order calculus, orthogonal expansions.Stationarity in the strict and wide senses. Ergodicity in the q.m.sense. Wide senseStationary processes

UNIT – IV:

Herglotz's and Bochner's theorems. Spectral representation. L2- stochastic integrals.Spectral decomposition theorem. Low-pass and band-pass processes. White noise andWhite-noise integrals

TEXT BOOKS:

1. Papoulis, S. U. Pillai, "Probability, Random variables and Stochastic processes" Tata-Mc Hill
2. R.B.Ash&C.Doleans-Dade, Probability and Measure Theory.

REFERENCE BOOKS:

1. E.Wong & B.Hajek, Stochastic Processes in Engineering systems, Springer, 1985
2. R.B.Ash & W.A.Gardner, Topics in stochastic processes, Academic Press, 1975.
3. Stakgold, I., Green's Functions and Boundary value Problems (e), Wiley, 1998.

TIME SERIES ANALYSIS								
Course Code	**CS 6E29**	**L-P-T-Cr.:**	**3**	**0**	**1**	**3**	**Semester:**	
Category:	Programme Elective Course							
Prerequisite:	Foundation of computer science and mathematics.							
Objective:	To understand the concepts of Time Series theory and methods of analysis.							

CO1	Remember and understand the basic concepts/Principles of time series analysis.
CO2	Analyse the Various Concepts to understand them through case studies.
CO3	Apply the knowledge in understanding practical problems.
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course.

(14 Hours)

UNIT-I

Stochastic process and its main characteristics Stochastic process. Time series as a discrete stochastic process. Stationarity. Main characteristics of stochastic processes (means, autocovariation and autocorrelation functions). Stationary stochastic processes. Stationarity as the main characteristic of stochastic component of time series. Wold decomposition. Lag operator. Autoregressive-moving average models ARMA(p,q) Moving average models MA(q). Condition of invertability. Autoregressive models AR(p). Yull-Worker equations. Stationarity conditions. Autoregressive-moving average models ARMA (p,q).

UNIT-II **(10 Hours)**

Coefficients estimation in autoregressive models. Coefficient estimation in ARMA (p) processes. Quality of adjustment of time series models. AIC information criterion. BIC information criterion. "Portmonto"-statistics. Box-Jenkins methodology to identification of stationary time series models.

UNIT-III **(12 Hours)**

Forecasting, trend and seasonality in Box-Jenkins model. Non-stationary time series. Time series with non-stationary variance. Non-stationary mean. ARIMA (p,d,q) models. The use of Box-Jenkins methodology to determination of order of integration. Non-stationary time series, TSP or DSP: methodology of research. Segmented trends and structure changes.

UNIT-IV **(12 Hours)**

Time series co-integration. Co-integration regression. Testing of co-integration. Vector auto regression and co-integration. Co-integration and error correction model. Granger causality. Hypothesis testing on rational expectations. Hypothesis testing on market efficiency.

TEXT BOOKS

1. Enders W. Applied Econometric Time Series. John Wiley & Sons, Inc., 1995
2. Mills, T.C. The Econometric Modelling of Financial Time Series. Cambridge University Press, 1999
3. Andrew C. Harvey. Time Series Models. Harvester wheatsheaf, 1993.
4. Andrew C. Harvey. The Econometric Analysis of Time Series. Philip Allan, 1990.

REFERENCES

1. Banerjee, A., J.J. Dolado, and D.V. Hendry. Co-Integration, Error Correction, and Econometric Analysis of Non-Stationary Data. Oxford University Press, 1993.
2. Maddala, G.S. And Kim In-Moo. Unit Roots, Cointegration, and Structural Change. Cambridge University Press, 1998.

COMPUTER BASED NUMERICAL AND STATISTICAL METHODS								
Course Code	**CS 6E30**	**L-P-T-Cr.:**	3	0	1	3	**Semester:**	**I**
Category:	Program Elective Course							
Prerequisite:	NA							
Learning Objective:	• To understand Computation and to make use the computers effectively for solving problems. Designing Flowcharts, algorithms for providing apt computation. • To familiarize students with statistical and numerical techniques needed in problem-solving and industrial applications.							

CO1	Remember and understand the basic concepts/Principles of Computer Based Numerical Statistical Methods
CO2	Analyze the Various Concepts to understand them through case studies
CO3	Apply the knowledge in understanding practical problems
CO4	Execute/Create the Project or field assignment as per the knowledge gained in the course

UNIT – I: **(10 hours)**

Introduction: Numbers and their accuracy, Computer Arithmetic, Mathematical preliminaries, Errors and their Computation, General error formula, Error in a series approximation

Solution of Algebraic and Transcendental Equation: Bisection Method, Iteration method, Method of false position, Newton-Raphson method, Methods of finding complex roots, Muller's method, Rate of convergence of Iterative methods, Polynomial Equations.

UNIT – II: **(10 hours)**

Interpolation: Finite Differences, Difference tables Polynomial Interpolation**:** Newton's forward and backward formula

Central Difference Formulae: Gauss forward and backward formula, Stirling's, Bessel's, Everett's formula. Interpolation with unequal intervals: Langrange's Interpolation, Newton Divided difference formula, Hermite's Interpolation,

Numerical Integration and Differentiation: Introduction, Numerical differentiation Numerical Integration: Trapezoidal rule, Simpson's 1/3 and 3/8 rule, Boole's rule, Waddle's rule.

UNIT – III: **(10 hours)**

Solution of differential Equations: Picard's Method, Euler's Method, Taylor's Method, Runge-Kutta Methods, Predictor Corrector Methods, Automatic Error Monitoring and Stability of solution

UNIT – IV: **(10 hours)**

Statistical Computation: Frequency chart, Curve fitting by method of least squares, fitting of straight lines, polynomials, exponential curves etc., Data fitting with Cubic splines, Regression Analysis, Linear and

Nonlinear Regression, Multiple regression, Statistical Quality Control methods.

TEXT BOOKS

1. Rajaraman V, “Computer Oriented Numerical Methods”, Pearson Education
2. Gerald & Whealey, “Applied Numerical Analyses”, AW

REFERENCE BOOKS:

1. Jain, Iyengar and Jain, “Numerical Methods for Scientific and Engineering Computations”, New Age Int.
2. Grewal B S, “Numerical methods in Engineering and Science”, Khanna Publishers, Delhi
3. T Veerarajan, T Ramachandran, “Theory and Problems in Numerical Methods, TMH
4. Goyal, M, “Computer Based Numerical and Statistical Techniques”, Firewall Media, New Delhi.